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THE CHEMICAL NEWS.

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POLYMERISATION AMONGST LIQUIDS.

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(Concluded from vol. cxxii, p. 293.)

BELOW I have calculated p for a number of typical *organic compounds. The results for some* hydrocarbons are given in Table VII.

TABLE VII.

Compound	Absolute Temp.	Sr.	S_{obs}	p
C_5H_{12}	273	2·682	0·512	5·23
C_6H_{14}	298	2·713	0·527	5·15
C_7H_{16}	298	2·683	0·504	5·32
C_8H_{18}	298	2·661	0·505	5·27
C_8H_{18}	345	2·767	0·578	4·79
C_9H_{20}	298	2·638	0·503	5·24
$C_{10}H_{22}$	298	2·631	0·498	5·28
$C_{10}H_{22}$	360	2·756	0·590	4·67
$C_{11}H_{24}$	298	2·618	0·501	5·22
$C_{12}H_{26}$	298	2·609	0·500	5·22
$C_{13}H_{28}$	298	2·601	0·499	5·21
$C_{14}H_{30}$	298	2·590	0·497	5·21
$C_{15}H_{32}$	298	2·586	0·497	5·20
$C_{16}H_{34}$	298	2·579	0·496	5·20
C_5H_{10}	403	2·688	1·060	2·53
C_5H_{10}	443	2·732	1·500	1·82
C_6H_6 (solid)	223	—	—	5·40
C_6H_6 (solid)	263	—	—	3·82
C_6H_6 (solid)	273	—	—	3·14 / 3·64
C_6H_6 (liquid) ...	283	1·7688	0·4066	4·35
C_6H_6 (liquid) ...	293	1·791	0·423	4·23
C_6H_6 (liquid) ...	313	1·819	0·4233	4·29
	323	1·838	0·4502	4·09
	367	1·895	0·481	3·94
C_6H_{12}	298	2·497	0·506	4·93
$C_6H_5CH_3$	181			
$C_6H_5CH_3$	248	1·786	0·380	4·69
$C_6H_5CH_3$	293	1·897	0·412	4·60
$C_6H_5CH_3$	358	2—	0·534	3·74
$C_{10}H_8$ (solid) ...	223	—	—	5·39
$C_{10}H_8$ (solid) ...	288	—	—	4·25
$C_{10}H_8$ (solid) ...	318	—	—	4·20
$C_{10}H_8$ (solid) ...	338	—	—	4·13
$C_{10}H_8$ (liquid) ...	356	1·723	0·396	4·35
$C_{10}H_8$ (liquid) ...	368	1·733	0·427	4·06

Conclusions.

1. The paraffins (saturated hydrocarbons) are highly but almost equally polymerised near their *boiling-points.*

2. The unsaturated hydrocarbon, amylene, is much less polymerised than the corresponding paraffin, although it has two free bonds, which would, one would have thought, have given it *additional associative power. Compare* C_6H_6 *and* C_6H_{12}.

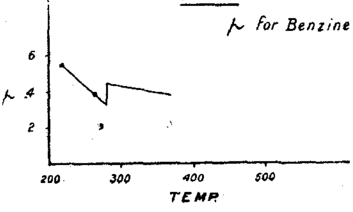
3. Benzene and naphthalene follow the phosphorus curve at their melting points.

4. The introduction of more hydrogen into the benzene ring, *i.e.*, the saturation of an unsaturated compound, still further raises p (*c.f.* C_6H_6 and C_6H_{12}).

5. The introduction of a side chain, *e.g.*, $-CH_3$, hardly affects p, but naphthalene is *slightly more polymerised than benzene.*

6. From the graph it will be seen how much more rapidly p (for naphthalene) falls in the solid than in the liquid state.

FIG. 4.



The influence of the halogens is shown in Table VIII.

TABLE VIII.

Compound		T	Sı	S_{obs}	p
CH_4	$CHCl_3$	243	0·4557	0·2203	1·99
	$CHCl_3$	273	0·4730	0·2323	2·03
	$CHCl_3$	333	0·5035	0·2384	2·11
	CCl_4	273	0·3683	0·2010	1·83
	CCl_4	343	0·3939	0·2031	1·94
C_2H_6	C_2H_5Cl	262	1·305	0·4276	3·26
	C_2H_5Br	168	—	0·195	—
	C_2H_5Br	244	0·808	0·205	3·94
	C_2H_5Br	281	0·8434	0·2164	3·90
	C_2H_5I	243	0·5606	0·1567	3·58
	C_2H_5I	273	0·5825	0·1616	3·60
	C_2H_5I	303	0·6031	0·1666	3·62
	C_2H_5I	333	0·6173	0·1715	3·60
	$C_2H_4Cl_2$	273	0·9168	0·2922	3·14
	$C_2H_4Cl_2$	303	0·9833	0·3054	3·22
	$C_2H_4Cl_2$	333	0·9711	0·3186	3·05
	$C_2H_4Br_2$	293	0·495	0·174	2·84
C_2H_4	C_2Cl_4	243	0·394	0·1925	2·04
	C_2Cl_4	273	0·410	0·198	2·07
	C_2Cl_4	373	0·445	0·228	1·95
	C_2Cl_4	413	0·454	0·243	1·87
C_6H_6	C_6H_5Cl	308	1·2585	0·3252	3·87

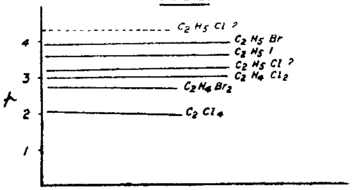
Conclusions.

1. The introduction of a halogen either into a saturated, unsaturated, or ring compound has the effect of reducing p, and the more complete the substitution of hydrogen the lower does p become (compare C_6H_6 and C_6H_5Cl; C_2H_5Br and $C_2H_4Br_2$).

2. In some cases there is a rise in the value of p with temperature, *e.g.*, $CHCl_3$ and CCl_4 (compare H_2O).

3. The polymerisation curves for C_2H_5I, C_2H_5Br, and $C_2H_4Cl_2$ are practically horizontal. It almost looks as if the specific heat of C_2H_5Cl was inaccurate, as the polymerisation curve for this compound should be above, and not below, that of the corresponding bromine compound. Compare the results for $C_2H_4Cl_2$ and $C_2H_4Br_2$. See Fig 5.

FIG 5.



The results for the alcohols are given in Table IX.

TABLE IX.

	T	ST	S_{obs}	p
HOH … …	273	—	—	1·88
$CH_3.OH$ … …	280	2·1515	0·5901	3·64
$CH_3.OH$ … …	306	2·215	0·645	3·43
$C_2H_5.OH$ … …	182	—	0·457	—
$C_2H_5.OH$ … …	253	2·154	0·5053	4·26
$C_2H_5.OH$ … …	313	2·342	0·6479	3·61
$C_2H_5.OH$ … …	353	2·384	0·7694	3·09
C_3H_7OH … …	269	2·256	0·5186	4·35
C_3H_7OH … …	293	2·328	0·579	4·02
n C_4H_9OH …	340	2·456	0·689	3·56
iso C_4H_9OH …	206	—	0·508	—
iso C_4H_9OH …	283	2·347	0·5022	4·07
iso C_4H_9OH …	313	2·392	0·6482	3·69
iso C_4H_9OH …	358	2·481	0·8413	2·95
amyl $C_5H_{11}OH$	224	2·224	0·455	4·88
amyl $C_5H_{11}OH$	263	2·290	0·482	4·75
amyl $C_5H_{11}OH$	348	2·482	0·695	3·57
iso $C_5H_{11}OH$ …	270	2·315	0·4985	4·64
iso $C_5H_{11}OH$ …	310	2·411	0·600	4·02
C_6H_5OH … …	293	1·610	0·561	2·86
C_6H_5OH … …	367	1·700	0·561	3·02
$C_6H_5.CH_2OH$ …	380	1·842	0·558	3·03
CH_2OH / CH_2OH … …	295	1·884	0·565	3·33
	308	1·898	0·591	3·21
CH_2OH / $CHOH$ / CH_2OH … …	306	1·705	0·576	3·12
C_2H_5 >O C_2H_5 … … …	182	—	0·514	
	223	2·215	0·517	4·28
	271	2·305	0·523	4·40
	303	2·383	0·547	4·35

Conclusions.

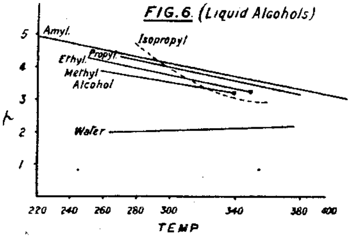
1. On substituting an organic radicle for one of the hydrogen atoms in water, p is considerably increased.

2. On graphing p against absolute temperatures it will be seen that the curves of methyl, ethyl, propyl, butyl, and amyl alcohols are almost parallel to each other, especially in their latter portions, so that at any temperature common to all curves the increment in the value of p due to $=CH_2$ is maintained. As we mount the series, the more polymerised is the alcohol at the melting-point; but at their boiling-points the values of p are all approximately equal to 3+, compared with $p=2$ for water, and $p=4+$ for ether. Thus,

	p (B.P.)
H >O H … … …	2·04
C_2H_5 >O H … … …	3·09
C_2H_5 >O C_2H_5 … … …	4·35

3. The curves for *iso*-alcohols are below those for normal alcohols, but at the boiling-point they are very much alike (see Fig. 6).

FIG. 6. (Liquid Alcohols)



(In Fig. 6 "Isopropyl" should read "Isobutyl.")

4. The effect of substituting a second organic radicle in the water molecule (*e.g.*, to form an ether) still further accentuates the above changes.

5. The effect of introducing the hydroxyl group into the benzene ring or the side chain of an aromatic compound is to reduce *p* (compare with Nos. 1 and 4).

6. *Glycol and glycerin are not so highly associated at the boiling-point as methyl alcohol, the first of the monohydric alcohols; neither are they so highly polymerised as the hydrocarbons from which derived.*

	$CH_3.H$ / $CH_3.OH$	$CH_3.CH_3$ / $CH_2OH.CH_2OH$	$CH_3.CH_2.CH_3$ / $CH_2OH.CHOH.CH_2OH$
T	306	308	306
p	3·43	3·21	3·12

The results for a few fatty acids are given in Table X.

TABLE X.

	Absol. Temp.	ST	Sobs	*p*
H.COOH (solid)	273	1·025	0·430	2·38
H.COOH (liquid)	310	1·286	0·552	2·46
H.COOH (liquid)	330	1·309	0·515	2·54
CH_3COOH (solid)	277	1·258	0·627	2·00
$CH_3.COOH$ (liquid)	308	1·572	0·5118	3·07
$CH_3.COOH$ (liquid)	323	1·591	0·537	2·96
$C_2H_5.COOH$ ...	343	1·808	0·536	3·37
$C_2H_5.COOH$ ...	351	1·811	0·560	3·23
$C_3H_7.COOH$ ...	333	1·916	0·526	3·64

Conclusions.

1. Formic and acetic acids, and probably the other members of the series, too, follow the phosphorus curve on melting.

2. As we ascend the series there is a rise in the value of *p*, coinciding with an increase in the percentage of carbon (the most important polymerising element present) from 26 per cent in formic to 54 per cent in butyric acid.

3. For the acids included in this table, *p* is less than for the corresponding hydrocarbons from which they are derived, which contain much more carbon.

A few nitriles are dealt with in Table XI.

TABLE XI.

	T	ST	Sobs	*p*
CH_3CN	321	1·746	0·541	3·22
C_2H_5CN	330	1·880	0·538	3·50
C_3H_7CN	340	2·111	0·547	3·86
$C_5H_{11}CN$	359	2·264	0·542	4·17

Conclusions.

1. The nitriles are slightly more polymerised than the acids they yield on hydrolysis.

2. As the percentage of carbon rises from 58·8 ($CH_3.CN$) to 74·2 ($C_5H_{11}.CN$), *p* changes from 3·22 to 4·17.

Other well-known compounds are included in Tables XII.—XV.

TABLE XII.

CH_3 \ CH_3 / CO ...	243	1·887	0·4825	3·91
	273	1·955	0·5064	3·86
	293	2·003	0·528	3·79
	303	2·024	0·5302	3·81
	333	2·075	0·5540	3·75
$C_6H_5.CO.CH_3$	383	1·758	0·474	3·71
$C_6H_5.CO.C_6H_5$				
,, (solid)	234	1·214	0·2300	5·28
,, (solid)	295	1·257	0·3051	4·12
,, (liquid	295	1·532	0·3825	4·00

The effect of nitration is shown in Table XIII.

TABLE XIII.

C_6H_6 (solid) ...	273	—	—	3·64
C_6H_6 (liquid) ...	283	—	—	4·35
C_6H_6 (liquid) ...	367	—	—	3·04
$C_6H_5.NO_2$ ...	280	1·305	0·3524	3·70
	293	1·323	0·358	3·69
	366	1·400	0·402	3·48
$C_{10}H_8$ (solid) ...	318	—	—	4·13
$C_{10}H_8$ (liquid) ...	356	1·743	0·306	4·35
$C_{10}H_8$ (liquid) ...	368	1·733	0·427	4·06
$C_{10}H_7.NO_2$ (solid)	316	1·120	0·274	4·09
$C_{10}H_7.NO_2$ (liquid)	331	1·302	0·300	3·87
$C_{10}H_7.NO_2$ (liquid)	367	1·424	0·300	3·65

TABLE XIV.

NH_3 (solid) ...	85	—	—	3·72
NH_3 (liquid) ...	273	—	—	3·05
$C_6H_5.NH_2$ ...	283	1·730	0·497	3·48
	366	1·840	0·538	3·43
$(C_6H_5)_2.NH$ ...	326	1·668	0·464	3·66
	330	1·714	0·482	3·56
C_6H_6	283	—	—	4·35
	313	—	—	4·29
	367	—	—	3·94

There is a gradual gradation in the degree of polymerisation as we pass from C_6H_6 to NH_3.

The results for CS_2 are given in Table XV.

TABLE XV.

	T	ST	S bs	*p*
CO_2 (solid) ...	140	—		2·82
CS_2 (liquid) ...	177	—		
	243	0·432	0·2303	1·88
	273	0·449	0·238	1·88
	303	0·464	0·240	1·93

In Table XVI. I have compared my results with those obtained by other investigators. The following is the key to the Table:—

R.S. = Ramsay and Shield's original surface tension method.

R-R.I. = Rose-Innes' modification of the R.S method.

B = Batschinski's *ditto.*

F = The present method.

TABLE XVI.

Compd.	Temp.	R.S.	R-R.I.	B.	F.
Water	273	3·81	1·707	2·82	1·8
	373	2·66	1·405	1·10	2·0
CH_3OH	?183	—	2·65	—	—
	280	—	—	—	3·6
	289	3·43	—	—	—
	293	—	—	3·43	—
	306	—	—	—	3·4
	339	3·24	2·17	—	—
C_2H_5OH	183	—	2·03	—	—
	253	—	—	—	4·2
	289	2·74	—	—	—
	293	—	—	4·43	—
	313	—	—	—	3·
	333	—	—	3·65	—
	351	2·43	1·46	—	—
	353	—	—	—	3·
C_3H_7OH	269	—	—	—	4·
	290	—	—	5·03	—
	293	—	—	—	4·
	340	—	—	—	3·
	353	—	—	3·15	—

C_4H_9OH	290	—	—	4·79	—
	340	—	—	—	3·56
	353	—	—	3·03	—
$C_6H_5.OH$	275-293	1·01	—	—	—
	293	—	—	—	2·86
CH_3 COOH	289	3·62	—	—	—
	293	—	2·13	3·47	—
	308	—	—	—	3·07
	323	—	—	—	2·96
	373	—	—	2·74	—
	391	2·9	1·79	—	—
$C_3H_7.COOH$	289	—	—	2·48	—
	343	—	—	—	3·37
	351	—	—	—	3·23
	406	—	—	2·26	—

Here T=T

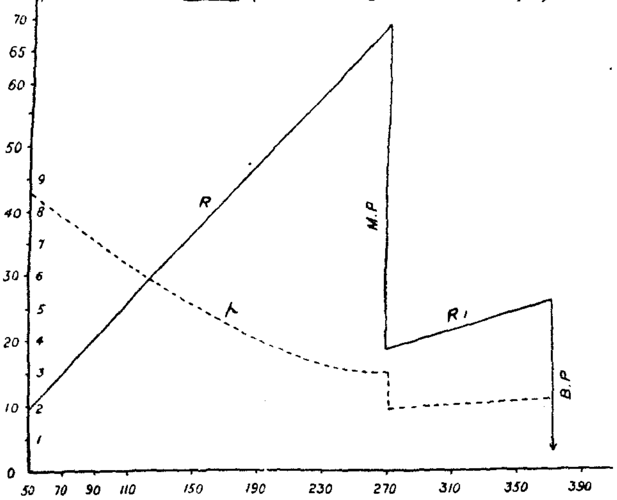
$$\therefore \frac{ps}{R} \cdot \frac{R_1}{p_1 s_1} = \text{a constant}$$

$$\text{Now } \frac{T+563}{37·7} = \sqrt{\text{Melticular weight}}$$

$$\therefore \left(\frac{T+563}{37·7}\right)^2 = R \times \text{average at. wt.}$$

$$\text{and } \left(\frac{T_1+136}{34·6}\right)^2 = R_1 \times \text{average at. wt.}$$

FIG. 7 (To show change in value of p & R)



Batschinski's and my results are often in close agreement, especially for the alcohols and acetic acid.

Appendix.

In the preceding paper nothing has been said about changes in the value of R (aggregations) on melting, &c., although changes in p and s have been noted. The vapicular weights were chosen without reference to the melticular weights.

At the M.P. (solid state)

$$\frac{T \times p \times s}{R} = k$$

——— (liquid state)

$$\frac{T_1 \times p_1 \times s_1}{R_1} = k_1$$

$$\therefore \frac{ps}{R} \cdot \frac{R_1}{p_1 s_1} = \frac{ps}{p_1 s_1} \left\{ \frac{\frac{T_1+136}{34·6}}{\frac{T+563}{37·7}} \right\}^2 = \text{a constant}$$

$$= \frac{ps}{p_1 s_1} \left\{ \frac{T_1+136}{T+563} \right\}^2 = \text{a constant}$$

Substituting the values for water we can find the constant and then R_1 with respect to R at the M.P. For water :—

$$ps = 1·5$$
$$p_1 s_1 = 2$$
$$T = 273$$

$$\therefore \left(\frac{T_1+136}{T+563}\right)^2 = \left(\frac{409}{836}\right)^2 = \frac{1}{4{\cdot}178}$$

$$\therefore k^{273}_{water} = 0{\cdot}191$$

Keeping R for ice at 273° = 69
∴ R_1 for water at 273° = 17·5

In Table III., R_1 for water at 273° was 23·3.
∴ to get R_1 in the liquid state, relative to the value in the solid state, multiply the values previously obtained for liquid state by $\frac{17{\cdot}5}{23{\cdot}3}$ or 0·751.

E.g., R_1 for bromine at 302° was taken as 2, ∴ if R = 5 for bromine at its M.P., R_1 at $302 = 2 \times \frac{17{\cdot}5}{23{\cdot}3} = 1{\cdot}5+$

If R or R_1 for any substance came to less than the number of atoms in the compound (or one, if an element), all values of R and R_1 must be raised to give these minimum values. The changes in the aggregations for water are shown in Fig. 7.

THE PHYSICAL PROPERTIES OF THE SOIL IN RELATION TO SURVEY WORK.*

By G. W. ROBINSON, M.A., Adviser in Agricultural Chemistry University College of N. Wales, Bangor.

CONSIDERABLE difficulty has been experienced in the correlation of plant and soil surveys. This may be attributed to a large extent to the defects of existing methods of soil classification. In the classification of any material, whether soils, plants, or animals, the method to be adopted is to a large extent arbitrary. For example, soils may be classified on a purely genetic basis, and, from the geological point of view, this classification is the one naturally to be adopted. From the point of view of plant physiology, however, a genetic classification may be of little use.

In many regions the genetic classification proves quite satisfactory even from the point of view of plant physiology, and the properties of a soil may be closely correlated with the conditions of its origin. Geology and climate are the principal factors in soil formation. Under conditions such as obtain over most of England and Western Europe generally, the influence of geology on soil is well exemplified. Hall and Russell, in their survey of the soils of Kent, Surrey, and Sussex, were able to classify soils satisfactorily on a geological basis. Under more extreme conditions of climate as exemplified by the semi-arid regions of South-Eastern Europe, and the extreme humid regions of our own islands, the influence of geology on soil is much less marked. Accordingly we find the Russian school of soil workers classifying soils largely on a climatic basis.

Working in North Wales, the writer has found the correspondence between geology and soil much less marked than in England. The rather extreme humid conditions may account for this to a large extent. Other observers have noted that under extreme conditions of climate, whether of temperature or rainfall, the influence of the parent rock is reduced to a minimum. The lack of correlation between geology and soil need not, however, prevent the investigator from establishing soil types. The question, of course, arises whether soil types always exist or whether in some cases soils are unclassifiable. In some districts the isolation of soil types is an impossible task. Among the glacial soils of certain districts of North Wales it is possible to find a continuous gradation from sands to clays without any definite grouping. In other areas soil types do undoubtedly exist, and a large number have already been described.

This leads to the question of the criteria used in soil classification and the isolation of soil types. At present, mechanical analysis is the general criterion used for the characterisation of soils. In this country the soil is separated into six grades of particles, varying from fine gravel to clay. There are, however, throughout the world, a large number of different conventions as to the limits of the size of the different fractions. Uniformity is impossible, as each country has accumulated too many data to effect a change. It is thus impossible to compare an English soil with, say, a Hungarian or a Swedish soil. Even in the case of the clay fraction where the upper diameter limit is taken as 0·002 mm., any comparison is vitiated by the different methods of separation in use. Another drawback to mechanical analysis, namely, the discontinuity of grouping, has been overcome by the elegant apparatus devised by Sven Odén, whereby the mechanical analysis of a soil can be expressed as a continuous curve.

The main defect of mechanical analysis, however, as a basis for soil classification, is that it only gives information as to the properties of the soil by inference. The mechanical analysis will tell us little about the properties of the soil beyond what is contained in the practical man's classification into sands, loams, and clays. Indeed, within certain limits, the same information might be gleaned by the ordinary methods of silicate analysis. In other words, the information given by mechanical analysis only differs in degree from that given by chemical analysis. The formula of an organic compound describes its constitution, but its properties are given by such constants as melting-point, boiling-point, and refractive index. The mechanical analysis of a soil is analogous to the constitutional formula of an organic compound.

Mechanical analysis is of undoubted value from the point of view of the genetic classification of soils. It enables the investigator to group together soils of similar origin. Apart from its diagnostic value, it gives certain indications as to the actual properties of the soil, but these are only imperfect and indirect. Attempts have been made to correlate cropping with mechanical analyses. The correlation is, of course, complicated by climatic and economic factors, but even allowing for these, the correlation obtained is imperfect and it may be doubted whether the mechanical analysis of soil can do more than standardise the practical man's classification of soils into heavy, medium, and light.

It is probably this defect in mechanical analysis which is responsible for the disappointing results obtained from soil surveys. Soil survey work has been in progress in this country for 15 years or more, while ecological studies have been carrie

*A contribution to a General Discussion on "Physico-Chemical Problems relating to the Soil" held by The Faraday Society, on Tuesday, May 31st, 1921.

on for an even longer period. Yet the actual progress in the correlation of plant and soil surveys is almost negligible.

In North Wales one frequently finds tracts where the edaphic conditions as indicated by the natural vegetation vary sharply from point to point without any apparent change of soil type. Differences in the air and water conditions of the soil are probably the main factors causing these variations, but there is no reliable quantitative method of expressing them. The mechanical analysis is almost useless, and can only occasionally be correlated with the natural vegetation. I am speaking, of course, of a province where the climatic conditions are somewhat extreme, but the same difficulty must frequently arise in districts of more moderate rainfall.

In the opinion of the writer, the only remedy for this, and the only way to get a fresh impetus for the field study of soils is to examine the soil from the point of view of its actual properties. To say that a soil contains 20 per cent of clay does not give a picture of the actual properties of the soil except by inference. In fact, certain materials, such as kaolin and finely ground slate, give as much clay by mechanical analysis as fairly heavy soils, although they lack the characteristic property of clays, namely, plasticity. Further, among the plastic clays, the amount of clay by mechanical analysis cannot be correlated completely with the texture.

Although the original data of mechanical analysis are quantitative, the deductions from them are certainly not quantitative. The most valuable data about the soil are those which give direct information as to the properties of the soil as they affect plant life. In the opinion of the writer, the data in question would be given by a series of physical constants comparable to those which are indispensable to the description of a newly-discovered element or compound.

An example of this method of investigation is furnished by Atterberg's work on the plasticity of soils. From the agricultural point of view, information as to the working properties of a soil is highly desirable, and the figures given by Atterberg's methods are of direct importance. His "Plasticity Number" gives the range of water content over which a soil is plastic, while the figures obtained by him for the cohesiveness of soils (festigkeit) give direct information as to the resistance of the soil to comminution by the ordinary operations of tillage.

Pore space as a physical constant for the soil would be of considerable use. Owing to the difficulties of obtaining a sample of the soil without disturbing its field structure, a satisfactory routine method for determining this value has not been devised. The methods of Kopecky and Trnka are instances of attempts to solve the problem. Could a satisfactory method be devised, it would be easy to determine to what extent it is specific for a given soil, and to follow the variations due to season and soil treatment.

Closely connected with pore space is the determination of water-holding capacity. Here again, some confusion reigns, partly due to the same difficulty of obtaining a sample with unaltered field structure. A constant to represent the permeability of soil for water and air would be of considerable value. Green and Ampt's methods, if they could be applied to investigation of natural soils, would be very suitable. The specific surface of soils has undoubtedly a physiological significance as a measure of the degree of dispersion. The methods of Mitscherlich, Hilgard, and others, for the measurement of hygroscopicity are worthy of attention, and it ought to be possible to devise some rapid routine method applicable to the study of soils on an extended scale. The problem has also been attacked by measuring dye absorption. In the opinion of the writer this method is not to be recommended, as it is liable to be complicated by chemical reactions between the dye used and soil constituents.

There are, of course, other physical properties of the soil on which quantitative ideas are needed, and it is to be hoped that the recognition of soil physics as a branch of investigation at Rothamsted will lead to a useful development of the work begun in this country by Warrington.

Whatever physical measurements may be devised for the investigation of soils, there are certain desiderata if they are to be of use in field study. Firstly, they must deal with the soil in its natural structure. The soil of the laboratory is an artificial product. Results obtained on it are apt to be misleading on the chemical side, and even more so on the physical side. The methods devised should also be capable of being repeated in large numbers. The soil is such a complicated object of study that statistical methods have to a large extent to remedy the unreliability of single observations. Methods to be devised for the physical investigation of the soil may have to sacrifice a little accuracy in order to make it possible to multiply observations in large numbers for the purposes of statistical treatment.

If reliable methods could be devised for characterising the physical properties of soils by a series of physical constants, the edaphic classification of soils might be placed on a much surer basis than at present and correlation with vegetation and agricultural conditions might be expected. The physical properties of a soil as expressed by such a series of constants would be of importance from the point of view both of plant physiology and of practical agriculture, since they would give quantitative expressions for factors which directly affect edaphic and cultural conditions. Supplemented by a few chemical and economic data, the agricultural properties of a soil could be completely characterised.

The investigation of the physical properties of the soil must in future be one of the most promising lines of inquiry. The soils of our country do not, as a rule, show any striking deficiencies in plant food capital and such deficiencies as do occur are easily made good. The ultimate productiveness of our soils is largely a matter of physical properties. With the new impetus given to the physico-chemical study of soils, of which this discussion is an evidence, it may be expected that the routine methods in use by field investigators will be more in the nature of physical determinations than of chemical analyses.

ROYAL INSTITUTION.—The General Meeting of the Royal Institution will be held on Monday, July 4, 1921, at 5 o'clock.

RUBBER RINGS IN CONNECTION WITH TEST-TUBES.

THE placing of a rubber ring around a test-tube about 1in. from the mouth has many advantages, as well as rendering the test-tube less liable to breakage in washing, knocking together, &c.

Having all my test-tube stands in use, and wishing to keep several others in a vertical position, the difficulty was soon overcome by driving one or two nails or long pins into the edge of a shelf and supporting the test-tubes in between the nails, as in Fig. 1.

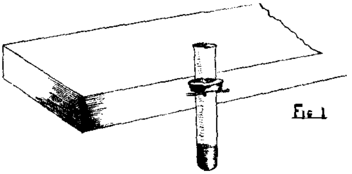


FIG 1

The use of a rubber ring on a test-tube has many other advantages, two of which are as follows:—

1. The tube can, if desired, be laid down on a bench (assuming, of course, that it is not too full) without losing any of the contents (see Fig. 2).
2. The ring permits the test-tube to be held in the fingers while very hot, during boiling processes, &c. The tube may also be supported by a hole in the shelf.

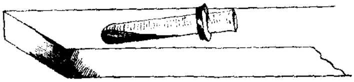


FIG 2

These rings are easily obtainable in all sizes, and should be about ⅛in. in thickness.

W.K.F.

NEW BRITISH CHEMICAL STANDARD.

HEMATITE IRON "B".

THIS standard, which is now available, has been prepared under the auspices of a body of analysts in order to meet a long-felt need in settling disputes as to the amount of phosphorus, sulphur, &c., in the purer varieties of hematite iron, as explained in a paper in the *Proc. Clev. Inst. Engineers* (*Middlesbrough*), No. 4, February, 1920.

The analytical standardisation has been carefully undertaken by a selection of experienced chemists representing all the chiefly interested parties, viz., one Government laboratory, three special hematite iron makers, four special hematite users, three independent analysts, and the U.S. Bureau of Standards.

The analysis is as follows: phosphorus 0·025 per cent; arsenic 0·031 per cent; sulphur 0·031 per cent; and titanium 0·108 per cent.

The standard may be obtained either direct from Organising Headquarters, 3, Wilson Street, Middlesbrough, or through any of the leading laboratory furnishers at a price just sufficient to cover the cost. A certificate, giving the names of the analysts co-operating, the types of methods used, and a detailed list of their individual figures, will be supplied with each bottle.

RADIUM.*

Chemical Effects of Radium Emanation.

DR. LIND is conducting a new series of experiments on the chemical effects of radium emanation in gas reactions. Improved apparatus was installed for eliminating hydrogen and oxygen gases from the emanation with additional equipment for final purification by liquid air. In a study of the combination of hydrogen and oxygen produced by α particles, it was discovered that the recoil atoms also produce chemical action proportionate to the ionisation.

Redetermination of the Spectrum of the Radium Emanation.—In co-operation with Prof. R. E. Nyswander, of Denver University, Dr. Moore and Dr. Lind continued the work of redetermining the spectrum of radium emanation. A number of lines have been successfully photographed and measured, and their identiy as part of the spectrum has been established with certainty; some of these coincide with the principal lines observed by other authorities, and the rest are apparently new lines.

Some work was also done in photographing the spectral lines of krypton and zenon furnished and purified by Dr. Moore.

Redetermination of Radium-Uranium Ratio.—Dr. Lind, of the station, and Prof. L. D. Roberts, of the Colorado School of Mines, concluded their investigation on the redetermination of the radium-uranium ratio, which they found to be $3{\cdot}40 \times 10^{-7} \pm 0{\cdot}03$. Results were published in June, 1920, number of the *Journal of the American Chemical Society.*

Dr. Lind also prepared the third section of a series of papers on methods of determining radium, published in the *Journal of Industrial and Engineering Chemistry.* The paper deals especially with improvements in electroscopes in recent years, and use of the X-ray electroscope in examining radioactive ores and other radioactive products.

Radium Fractionation.—Dr. Moore and Dr. Lind assisted the officials of the Minerals Recovery Co., of Denver, in overcoming difficulties they have experienced in radium fractionation. This company purchased and is operating the plant for treating carnotite ores built by the National Radium Institute.

Luminous Paints.—Experimental study of the properties of radium luminous paint continued throughout the year. Photometers for luminosity measurements were standardised, and a table prepared to convert the readings in centimetres into *microlamberts.*

A method was worked out for the preparation of pure zinc sulphide, and a quantity of the pure nonluminous salt was obtained. The action of radium emanation on the pure salt is being studied and this study will be continued on the prepared phosphorescent material.

*Extracted from the Tenth Annual Report of the Director of the *Bureau of Mines, U.S.A., for year ended June 30, 1920.*

ON CHEMICAL AFFINITY.

By A. KOREVAAR.

When we peruse the chemical literature and notice the meaning of the word affinity, it soon becomes clear that two different things are called by this name. In the first place, we know the classic definition of affinity coming from the Greek philosophers, and which denotes a force, acting between combining atoms. In the second place, modern chemistry shows us the thermodynamical conception of affinity, created by van't Hoff, which defines affinity as the maximum external work done by the chemical reaction at constant temperature and volume.

We, therefore, find the chemists using two quite different definitions of chemical affinity. It is to be expected that such a state of affairs will cause a confusion in our science, and this is really the case. The different text-books on chemistry define affinity quite differently. One maintains the classical definition, a second gives the thermodynamical one, and others mix both definitions up in a wonderful way, some even advocating removing this vague idea from chemical science.

This last would not be right. Neither the classical nor the thermodynamical conception is indefinite; but we must always remember that the word affinity denotes two quite different ideas. At present this is not generally known. This appears clearly from the confusion on this point, existing in our text-books, as shown by the following examples:

Lewis, in his "A System of Physical Chemistry," 1920, ii., 339, gives the definition by van't Hoff; Holleman, in his text-book of inorganic chemistry, 1906, p. 47, the classical conception. Ostwald, in his "Grundlinien der anorganischen Chemie," 1904, p. 88, discusses the classical conception and advises not to use this idea, because he thinks it in contradiction with certain phenomena which, on p. 104 appear to be the reversible reactions.

J. W. Mellor, in his "Modern Inorganic Chemistry," 1912, p. 94, deals first with the classical conception, but does not stick to it further on, while R. de Forcrand, in his "Cours de Chimie," 1919, does not speak at all about affinity.

Ostwald's attitude in his "Der Werdegang einer Wissenschaft," 1908, is quite remarkable. In this book, Chapter VI. deals with affinity. In fact, in the beginning the author writes about affinity, but soon he enters into thermodynamical considerations without giving an analysis or description of the idea "affinity," and the reader gets the impression that the author does not know what he shall say on this point.

The cause of all this is quite clear. The authors are not conscious that two different ideas are called by the same name "affinity."

We hope that this short explanation may cause the different authors to revise their texts on this point, and that they will not only rigidly separate the classical from the thermodynamical conception; but also that they will call these different ideas by different names. The best were perhaps to continue to call the classical conception by the name "affinity," and to denote the thermodynamical one by the maximum external work of the reaction.

O. Sackur ("Die chemische Affinität und ihre Messung". Vieweg, 1908) has contributed to a great extent to the existence of the above-mentioned confusion. His book on chemical affinity is well known and justly admired, as it gives a clear and simple treatment of the maximum external work, and its applications to chemistry. But this author has totally forgotten that *the classical conception of affinity has still a right to exist.* Sackur begins in the first chapter with a historical development of the idea of affinity, and we might expect that, in doing this, he would have discovered the confusion of ideas in question. But the author has failed to do so, and therefore it is worth while to trace the historical line once more and show how it has been possible that chemical science gave birth to two different definitions of chemical affinity.

We may say that the conception of affinity as a force between the smallest particles, or in the middle ages, when the atomic theory was denied on the authority of Aristotle, as a force between the elements, remained invariably the same till the end of the 18th century. It is true that the nature of these forces was differently explained. The Greeks had an antropomorphistical conception of affinity, and this character was preserved till the 17th century. The force, driving different substances together, was compared with love between two human beings. With the rise of the mechanical contemplation of nature in the 17th and 18th centuries, the ideas on the nature of chemical force became more sober. Lemery (1675) thought the atoms were provided with little hooks for sticking to each other. Newton classified the chemical force under the gravitation of the smallest particles; but according to him it was not necessary that this force was, as with visible masses, inversely proportional to the distance. This latter restriction was dropped by Buffon (1770), who saw no difference between chemical force and gravitation.

In all of these theories the driving force of a reaction was considered acting between the smallest particles of the combining substances. The difficulties arose when Berthollot proved experimentally that the progress of a reaction not only depends on the nature of the reacting substances, but also on their quantity, or, as Guldberg and Waage proved afterwards, on their concentration. These researches led, in 1864, to the formulation of the law of mass action. Guldberg and Waag's views are of the greatest importance for our purpose, and so we will pay some further attention to them.

Guldberg and Waage published their views in three treatises, which are collected in Astwald's Klassiker, No. 104, under the title: "Untersuchungen über die Chemischen Affinitäten" The treatises are dated 1864, 1867, and 1879, and we are not surprised that the ideas of the authors have developed in that course of time. In fact, we shall see that their conception of chemical affinity has undergone radical changes. Their views may be summed up as follows:

A substance A and a substance B combine, by the operation of cohesive forces between the molecules, to a compound AB. When a substance C reacts with AB according to the equation

$$AB+C=AC+B,$$

then, AC is principally produced by cohesive forces between A and C. But the forces between A and B, and perhaps also between B and C, have

all exerted their influence on the reaction, so that the force that finally produces AC is the result of the co-operation of different forces. This resultant force k is the coefficient of affinity. According to these investigators, the driving force of a reaction is not only proportional to the coefficient of affinity, but also to the concentrations of the reacting substances. While formerly only the affinity was considered to be the driving force of a reaction, according to the new conception, the affinity is only a part of the driving force. *The affinity has to be distinctly distinguished from the driving force of a reaction, they are quite different things.*

Guldberg and Waage expressed the driving force of a reaction by the product of the concentrations of the reacting substances and the coefficient of affinity k. When these concentrations are denoted by p and q, then the driving force $= kpq$. The authors originally thought that in determining k, they had found a measure for the affinity, for k was the resultant of the forces, acting between the molecules; but on this point they changed their views fundamentally. This appears form their treatise of 1879, where the idea of mobile equilibrium is developed in the following way.

To explain a reaction according to the equation:

$$A+B=A'+B',$$

it is insufficient to accept cohesive forces between the molecules, but it is also necessary to keep account with the motion of the atoms and molecules. The equilibrium is not a state of repose, it is a mobile equilibrium, the reactions in both directions going equally fast. The authors give a sketch of a kinetical deduction of the law of mass action. If p and q are the number of molecules of A and B in the unit of volume, then the number of collisions between the molecules A and B is represented by the product pq. When each collision caused a reaction, the reaction velocity would be $=Qpq$, Q being a velocity coefficient, dependent on temperature. Of p molecules of A, only a part a will be in a condition to cause a reaction during a collision. Of q molecules of B, a part b is in a similar condition. So that ap molecules of A will combine with bq moleules of B, and the reaction velocity is: $Qapbq$ or kpq when $k=Qab$. It is clear that this formulation is based on a quite different conception of k. At present this constant k is the product of a velocity coefficient Q and two constants a and b, which are perhaps best called activity coefficients. For the present it is impossible to determine these constants separately.

Concerning their views on chemical affinity, we conclude from their treatises the following: Guldberg and Waage certainly adopt the classical idea of affinity, viz., the affinity being a force acting between the molecules. This is clear from their former treatise, and appears in the mathematical treatment of the problem from the meaning of k. Their later considerations about the mobile equilibrium do not contradict the classical definition of affinity, but the meaning of k has become much more complicated and their conception of affinity is not clearly defined. The great importance of Guldberg and Waage's work does not lie in the sphere of affinity, and their great success is due to the formulation of the law of mass action, which became the basis of chemical statics and dynamics. At present, the names of these investigators are always connected with the law of mass action, but never with chemical affinity, though this was originally the object of their researches.

Though they did not do it themselves, and though, as far as we know, others did not do it either, we may draw from Guldberg and Waage's treatises a conclusion of importance. We have learned to make a sharp distinction between affinity as a force, acting between the smallest particles and the driving force of a reaction. This is clearly expressed in their original formula

$$\text{Driving force}=kpq.$$

The driving force of a reaction is quite different from the affinity.

Though we are convinced that k is in some way connected with the affinity, it appears from the later treatise of Guldberg and Waage that this connection is not a simple one. It is true that they succeeded in determining k, but the ydid not know the exact meaning of k. This is the reason that all determinations of affinity have failed.

In 1883, van't Hoff showed that the driving force of a reaction can be measured by the maximum external work at constant temperature and constant volume which is done by the system in passing from the initial state to the equilibrium point. This thought has been of the greatest importance for chemical science, but it was a great pity that van't Hoff called the driving force a reaction, affinity ("Vorlesungen über theoretische und physikalische Chemie," 1901, i., 171) and in consequence, considered the maximum external work of a reaction a measure for affinity.

In the preceding pages we have emphasized the difference between the driving force and affinity. By calling the driving force, affinity, van't Hoff has made the clear distinction between these two different ideas very vague. This was unnecessary. The maximum external work is a sharply defined idea, which does not need any other name, and it was a pity, for it caused a confusion, which, as we have seen, remains in our text-books up to the present day.

After this digression we return to Sackur's historical treatment of affinity. Sackur did not understand the confusion of affinity and driving force. According to him, the thermodynamical conception of affinity has gradually developed from the classical one. If this were true, the modern formulation would have made the ancient one superfluous, for then the modern one, by a broader development of the idea, would have opened a new insight, given us a new view-point, which would have included the old one completely. This did not happen, and Sackur writes unjustly that van't Hoff succeeded in "*eine glückliche Definition der Affinitätskraft aufzustellen, die allen bisherigen Erfahrungen Rechnung trägt und gleichzeitig die quantitative Messung in mechanischen Massen ermöglicht.*"

No, van't Hoff has mixed up the ideas of driving force and affinity; but, by calling the driving force affinity, the classical idea of affinity does not become superfluous. Therefore it is not true that van't Hoff's affinity, as Sackur says: "*allen bisherigen Erfahrungen Rechnung trägt.*"

It is better that the maximum external work of a reaction remains the maximum external work. Then, it is clear to everybody that the affinity is not meant. That is the question, and as Sackur

did not understand it, his much-read and otherwise excellent book is also responsible for the confusion which prevails in this sphere of chemical science.—*Journal of Physical Chemistry*, April, 1921.

PROCEEDINGS OF SOCIETIES.

ROYAL SOCIETY.

Ordinary Meeting, June 16, 1921

PROF. C. S. SHERRINGTON, President, in the Chair.

THE following papers were read:—

"*Velocity of Sound in Gases at High Temperatures, and the Ratio of the Specific Heats.*" By H. B. DIXON, F.R.S., COLIN CAMPBELL, D.Sc., and A. PARKER, D.Sc.

"*The Ratio of the Specific Heats of Air and of Carbon Dioxide.*" By J. R. PARTINGTON, D.Sc.

The ratio of the specific heats, $\gamma = c_p/c_v$, has been determined by the method of adiabatic expansion for the gases air and carbon dioxide. The gas was contained in a 120-litre vessel, and the temperature change immediately after expansion followed by a platinum thermometer, with compensating leads of wire 0·001 mm. diameter, the resistance of which was observed by an Einthoven string galvanometer of 0·01 seconds period. The fundamental temperature measurements were made by a mercury thermometer. The results were calculated by the characteristic equation of D. Berthelot, so that deviations from the ideal gaseous state were allowed for. The final results, which are believed to be accurate to 1 part in 1000, are: γ for air at 17° C. = 1·4034; for carbon dioxide at 17°C. = 1·3022. From these numbers the specific heats of the gases were calculated by Berthelot's equation, with the following results: c_p for air at 17° C. = 0·2387 cal.; c_p for carbon dioxide at 17° C. = 0·1996 cal. All the values refer to atmospheric pressure.

"'*Light Body*' *Hydrophones and the Directional Properties of Microphones.*" By A. B. WOOD, D.Sc., and F. B. YOUNG, D.Sc.

Prof. W. H. Bragg's theory of the vibration under water of a rigid body of low density has been tested. It is found that a light prolate ellipsoid actually possesses directional properties by virtue of its shape. Quantitative results obtained agree with calculated values supplied by Prof. Lamb.

Owing to the pronounced intrinsic directional properties of the microphone (when suitably mounted), a spherical "light body" hydrophone is practically equal in directional efficiency to one of ellipsoidal form.

Though "light body" hydrophones are not so sensitive as hydrophones of other types, a miniature spherical one proved of great value as an experimental exploring instrument.

"*Acoustic Disturbances produced by Small Bodies in Plane Waves transmitted through Water, with Special Reference to the Single Plate Direction Finder.*" By A. B. WOOD, D.Sc., and F. B. YOUNG, D.Sc.

The experiments were undertaken primarily with the object of elucidating the action of the single plate direction finder—an instrument designed for detecting the direction of a source of sound submerged in water.

Sound distribution was explored round a number of discs immersed at a distance from a small submerged source of sound. By means of a pair of miniature hydrophones—one bi-directional, the other non-directional—it was possible to chart (1) direction of oscillation of the water particles; (2) relative amplitude of the movements; (3) relative amplitudes of the pressure oscillations.

The charts obtained fall broadly into two classes, according as the discs are solid or contain air-filled cavities, very minute air-filled spaces giving marked effects. Charts are shown of sound distribution round both the bi-directional and the uni-directional direction finders.

The behaviour of a typical baffle-plate is investigated. No satisfactory theory of the baffle can be offered to cover all experimental facts.

An Appendix deals with the exploration of the acoustic field produced on the reservoir by a small source of sound.

"*Some Problems connected with Evaporation from large Expanses of Water.*" By M. A. GIBLETT.

The water which falls as rain, &c., is originally evaporated from the earth's surface, in particular from the oceans. It is therefore important to ascertain how the evaporated water distributes itself in an atmospheric current during its progress across a water-surface, and how the amount of water rendered available depends on the length of the path over the surface and on meteorological conditions.

These problems are considered for a current of air of uniform speed, moving over a water-surface of uniform temperature. In the immediate vicinity of the surface is a thin layer of air through which water-vapour diffuses slowly by molecular processes, but above this is a rapid transition to a turbulent *régime*, where diffusion becomes much more rapid. Account is taken of the complex molecular processes at and near the water-surface, by means of an empirical evaporation formula, and the problem is treated as one of eddy-diffusion with this as boundary condition.

Formulæ are obtained for humidity at any point of the air-current, and for rate of evaporation from stretches of water extending any distance downwind. Introducing numerical values for the constants in the empirical formula, the distribution of water-vapour is obtained for some typical cases, and an estimate made of the rate of evaporation from long stretches of water under various conditions of wind, water-surface, temperature, and turbulence. The formulæ are employed to examine the nature and magnitude of the effect which each of the last-mentioned elements may exert, when varied within their natural range, and to compare the evaporation under different sets of possible conditions. The results emphasize, amongst other things, the control exercised by atmospheric turbulence over evaporation from large areas.

"*The Photographic Efficiency of Heterogeneous Light.*" By F. C. TOY, M.Sc., A.Inst.P.

This paper investigates the question of the action of heterogeneous light on the photographic plate. Two possible laws of action are discussed:—

(1) All the different radiations composing the heterogeneous beam may act simultaneously but independently, *i.e.*, each may act as though the

others are not present.

(2) All radiations may act simultaneously, but not independently.

This question is investigated theoretically, and it is shown that the possibility of testing it experimentally depends on the form of law connecting the probability of a single grain of the photographic emulsion being made developable with the intensity of the exciting light. The form of this law, recently proved experimentally by Slade and Higson, is considered, and a result is deduced which can be directly tested by experiment. From the evidence thus obtained it is concluded that over the spectral range used in the experiments (λ4350 to λ4000) radiations of different frequencies do not act independently in producing the photographic effect, but simply as a total amount even when a difference in quality exists.

NOTICES OF BOOKS.

Famous Chemists: The Men and Their Work. By Sir WILLIAM TILDEN, F.R.S., D.Sc., LL.D., Sc.D., Professor Emeritus of Chemistry in the Imperial College of Science and Technology. London: George Routledge & Sons. New York: E. P. Dutton & Co. 1921. Price 12s. 6d. net.

THE above work by Sir William Tilden is not a history in the usual sense of the word, it is rather a series of sketches collected with much apparent care of the lives of many men of the past whose names and work are familiar enough in the scientific world, and well-known to the educated public. The work is of peculiar interest, for the author has related in a very charming manner many details in the lives of those great men of whose labours we are reaping the fruit, while he has unconsciously added not a little of his own personality. As a result, the book has a fascination that those who know the author can very fully appreciate.

Sir William, in arranging the material for his book has taken for a guiding principle the Evolution of the Atomic Theory from the early idea of the chemical element, the Laws of Combination, Application of the Atomic Doctrine to the explanation of chemical phenomena, the application of the idea of Valency to the constitution and structure of the Molecule, and the study of the Properties of Atoms. The men whose lives are recorded are those who have taken a leading part in researches in this domain.

The material of the work is arranged in ten groups, commencing with Robert Boyle as the father of chemistry in 1691, through the period of the Phlogistians, to Scheele in 1786, and then on to the Anti-phlogistic Revolution in 1794, where we have the melancholy history of Lavoisier told with a pathos that enhances the interest in one of the saddest deeds of the French Revolution; the account is so vividly told that in reading it one seems to be carried back into the scenes of that very dark time. The animosity of Murat brought about by the fact that he once attempted to make himself prominent in connection with physical science and had propounded a "Theory of Fire" that was condemned by Lavoisier in no measured terms—the disgraceful behaviour of the chemist Fourcroy—the lodgment in the Port-libre prison—the frantic efforts of his devoted wife to obtain his release—the pathetic letter that he wrote to her begging her not to exhaust herself in useless efforts, and the last scene, when, having first witnessed the end of his friend and father-in-law Paulze, he was placed under the axe, constitute one of the saddest pages in human history. "The world has seen many revolutions since that day, and other revolutions will arise so long as injustice continues to be imposed by the few on the many."

The application of Electricity to the service of Chemistry is introduced by a clearly-written biography of Sir Humphry Davy, which is very fully illustrated; the Poet-Chemist seems to live again, and in reading the account one passes from one place to another in the life of this remarkable man with an interest that makes it difficult to lay the book aside; in these days of after-war darkness, with strikes, labour troubles, murders, and the nauseating activity of the divorce courts, it is interesting indeed to follow the mind of Davy in one of his early poems.

> Is this a time of minstrelsy,
>   When Nature rests in deathlike sleep,
> And roots and buds and herbage lie
>   Embalmed in cerements deep.
> It is a time of minstrelsy,
>   For round these walls what magic forms
> Appear in grace and harmony;
>   The pencil of the artist warms.
> The coldest scenes and powers sublime,
>   Awakening moral forms of things,
> And new creations steal from Time
>   His scythe, and close his wings.
> It is a time of minstrelsy,
>   For social converse wakes the mind
> To pure and happy sympathy;
>   And elegance and taste refined.
> Call to the hospitable board
>   The force of reason, and the flow
> Of memory with wisdom stored
>   Which might awake a grateful glow.
> In Fancy e'en though checked by age,
>   Make sunshine in the darkest day,
> And kindle in the coldest sage
>   Some strain of vocal minstrelsy.

Many illustrations are given, including the humorous sketch of the Theatre of the Royal Institution by Gillray, where Davy, acting as assistant, is seen administering a dose of some gaseous compound to a trustful member of the audience.

The life history closes with a reproduction of the tomb of Davy in the cemetery of Geneva.

The life of Faraday falls on to Group VI., "Electro-Chemistry," and there is to be found a fund of information that fails in interest only by the fact that the history has been written so frequently.

In the chapters headed "Molecules and Atoms Defined" are to be found the lives of Avogadro and Cannizzaro, followed by Liebig, Dumas, Frankland, and Williamson, and the last groups are devoted to Mendeleeff, Crookes, and Ramsay.

The life and work of Crookes is given in great detail, accompanied by a good recent portrait that was taken in his study, together with several photographs of the Laboratory in Kensington Park Gardens; the account is strictly accurate, as can be vouched for by the writer, who acted as his private assistant from 1881 until his death. Sir William Crookes was very retiring, and but little is known of his private life.

The life of Ramsay has more the character of narrative than that of Crookes; the brilliant researches that led to the discovery of the inert

gases of the atmosphere are in themselves sufficient to fill a volume, and indeed that has already been done by Sir William himself in his "Gases of the Atmosphere." In the sketch before us, the life and the work of the man are happily blended together, and the reproduction of some letters written from Bombay and on board ship on the occasion of an official visit to India are full of human interest and touches of humour that will be prized by those who had the pleasure of his acquaintance.

The book ends with an "Epilogue" in which the recent developments in chemical theory brought about by the demonstration of the properties of radioactive matter are briefly reviewed.

The work is certainly one of the most interesting that has appeared since the war, and by its publication the author has brought a real pleasure within the reach of all lovers of pure science, and many a tired one will be grateful for a few hours' quiet spent over "Famous Chemists: The Men and their Work."

J.H.G.

Bibliotheca Chemico-Mathematica Catalogue of Works in Many Tongues on Exact and Applied Science. With a Subject Index compiled and annotated by *H.Z.* and *H.C.S.* With 127 plates, containing 247 Portraits and Facsimiles. Vol. I. London: Henry Southern & Co. 1921. In two volumes. Price 3 Guineas net.

This remarkable work (the writer of the preface modestly calls it a catalogue), was commenced in 1906, and gradually assumed the proportion in which it now appears, occupying two well-bound volumes, and extending to 964 pages. The work is claimed to be the first historical catalogue of science that has been published; it is certainly the most complete that we have seen, and will undoubtedly be welcomed by all lovers of books. The illustrations, which form the striking feature of the work, are half-tone plates printed on special paper, and include besides facsimiles of illustrations and portraits, textual passages from the more important works; it is claimed that many of them are reproduced for the first time

The books are arranged in alphabetical order, together with the price, bibliographical particulars, and historical references.

The value of the work is still further enhanced by the inclusion of a very complete Index, which embraces not only the books in the catalogue, but also those of further lists that have been published since the "Chemico-Mathematica" was printed; this, although it lacks the interest due to the illustrations that are given in the main volume is in itself a valuable asset. The authors express their indebtedness to Heinrich Zeitlinger of Linz, "a well-wisher of learning and of England," to whom is due the greater part of the work.

J.H.G.

Extra Pharmacopœia of Martindale and Westcott. Revised by W. HARRISON MARTINDALE, Ph.D., F.C.S., and W. WYNN WESTCOTT, M.B. (Lond). D.P.H. Seventeenth Edition. Vol. II. London: H. K. Lewis & Co., Ltd. 1921. Price 17s. 6d.

This volume forms an addition to Vol. I., which was issued in June, 1920. The authors state in their preface that they have submitted many of the statements that have appeared in recent scientific literature to laboratory test; the general results of these experiments are given in alphabetical order in the early pages of the book. These practical notes cannot fail to be of value. The section includes a short but comprehensive account of the science of Radiology Ultra-Violet Light. Of course, it is not intended to be other than a condensed note, but the condensation has been pushed to such a degree that we almost fear it may be misleading. In referring to the theory of Isotopes, we notice the bald statements that "Mercury is composed of five or six isotopes, Neon is a mixture of isotopic elements of different weights, as is also Chlorine." Should this meet the eye of a pharmaceutical student with but little knowledge of modern science, the result might be confusing.

The Bacteriocidal and Clinical notes are extremely good and valuable. The general contents and scope of the work are so well known that it is not necessary to go further; but enough has been said to make it clear that it has been brought quite up-to-date and contains its full value of information.

J.H.G.

The Condensed Chemical Dictionary. Compiled and Edited by the Editorial Staff of the Chemical Engineering Staff of the *Chemical Engineering Catalog* (F. M. TURNER, Jr., Technical Editor). Pp. 525. New York: The Chemical Catalog Co., Inc., 1, Madison Avenue.

This book gives a list of chemical substances in alphabetical order, giving their synonyms (if any), colour, and properties, constants, solubility, containers, uses, railroad, shipping regulations, &c.

This should prove a valuable help to not only the non-technical mind, but also to the chemist, who comes up against substances of which he wants a little knowledge, but being not directly concerned with it in his everyday routine of business, has generally to search through either one of the big dictionaries on chemistry or an academical treatise.

To give an example of the method employed in this book, one is taken at hazard:—

Dioxyanthraquinone (*Chrysazine*)

$C_{14}H_6O_2(OH)_2$ 1 : 8.

Colour and properties: Reddish-brown needles.
Constants: Melting-point 191° C. Soluble in alcohol; sparingly soluble in water.
Derivation: From dinitroanthraquinone (1 : 8) by reduction and subsequent diazotization.
Method of purification: Crystallisation.
Grades: Technical.
Containers: Wooden kegs.
Uses: Dyestuffs.
Fire hazard: None.
Railroad shipping regulations: None.

The dictionary is primarily compiled for the use of exporters and importers, brokers, lawyers, insurance companies, and many other classes of firms and individuals who have frequent need for information regarding chemicals and chemical products. Beside the dictionary proper there are a few pages relegated to the definition of units, also temperature conversion tables, &c. It should prove very useful to those for whom it is intended.

N.B.M.

Elementary Practical Chemistry. Part I., *General Chemistry.* By FRANK CLOWES, D.Sc. (Lond.), and J. BERNARD COLEMAN, A.R.C.Sc. Seventh Edition. Pp. xvi+241. London: J. & A. Churchill. 1920. Price 6s.

This little volume is especially intended for pupils of secondary schools, and other students who are not training for the profession of consulting and analytical chemistry. It accordingly comprises a course of instruction which gradually presents the principles of chemistry to the student by means of a selected series of experiments.

It commences with a description of the metric system of weights and measures, and the determination of density and temperature. Concise directions are then given for the preparation and use of some simple bench apparatus, such as the making of a wash-bottle, and the mounting of a platinum wire. The student next studies the composition of air and water, the process of combustion, and the properties of some important non-metals and metals and their compounds.

Many quantitative experiments are given, including some which illustrate the laws of chemical combination and of chemical equivalence, and the relation of acid to alkalis as regards their neutralising power.

The book is divided into fourteen sections, the last being comprised of miscellaneous exercises, such as the preparation of crystalline salts, &c. An Appendix is added in which is given a list of atomic weights, chemical equivalents of elements, conversion of tables of thermometer scales, and other data useful to the student.

N.B.M.

A Text-book of Organic Chemistry. By A. F. HOLLEMAN, Ph.D. Edited by A. JAMIESON WALKER. Fifth Edition. Pp. xviii.+642. 1920. London: Chapman & Hall. Price 18s. 6d. net.

The first English edition of this text-book was published in 1903, and it has just appeared in its fifth edition, which shows how much the author's work has been appreciated. In the two parts the whole field of organic chemistry is well covered. The first part deals with the aliphatic compounds; the second with the cyclic compounds. There are illustrations occurring through the book to render the text more easily understood. The book has a good index, which runs into 32 pages.

N.B.M.

Laboratory Manual of Organic Chemistry. By HARRY L. FISHER, Ph.D. Pp. x+331. London: Chapman & Hall, Ltd. 1920. Price 12s. 6d. net.

The book is divided into two parts: Part I., headed "Laboratory Experiments," gives a series of experiments both on the detection of organic radicles and the preparation of organic compounds. This part includes 66 experiments, and the author has marked the most important of them with an asterisk; that is to say, students who are not taking chemistry as a profession but must have a general groundwork in the subject, such as medical students, would only tackle those so marked.

Part II., entitled "Organic Combustions,' deals with the quantitative analysis of organic radicles; division A dealing with the determination of carbon and hydrogen; division B with nitrogen.

N.B.M.

Die Schwimmaufbereitung der Erze. By Dr. PAUL VAGELER. Dresden and Leipzig: Theodor Steinkopf. Price 4s. 4d.

The use of flotation methods for the concentration of ores has been greatly extended recently, and is now widely employed in various parts of the world, and for many different kinds of ores. More than 70 million tons of ore are now treated by flotation processes annually, and there is every reason to believe that this does not represent by any means the maximum amount that can be reached, although it does not appear at all probable that wet methods will ever be entirely superseded. This book, which is a short *resumé* of the work that has been done upon the theory and practice of these processes, comes at an opportune moment, and will be found to give a useful outline of the subject. The factors to be taken into account in applying the method are reviewed shortly, and such questions as the choice of oils are well discussed and summarised. The author is inclined to claim too much for German skill and enterprise, and the references to English and American literature are distinctly inadequate, while the lists of potent specifications include only those taken out in Germany. Hence there are many omissions of very important patents which considerably reduces the value of the book. The author attributes most of the advances that have been made to the work of German chemists, and evidently considers that the methods of "patent trial" adopted by the scientific men of other nations are hardly to be regarded as true research work. However, the book has a real value as a careful compilation and summary, and in many cases it indicates the directions in which useful research work is waiting to be done.

CHEMICAL NOTICES FROM FOREIGN SOURCES.

Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences. Vol. clxxii., No. 23.

"On Titanium Peroxide."—By M. Maurice Billy.

"Contribution to the Study of Oils derived from Grape Pips."—By M. Emile André.

"On Some New Sulphonate Derivatives of Oxindol and Isatin."—By MM. J. Martinet and O. Dornier.

"Allotropic Modifications of Oxides."—By Mdlle. S. Veil.

"Preparation of Mixed Secondary and Tertiary Phenolic Amines."—By M. A. Mailhe and F. de Godon.

No. 24.

"Surface-tension of Mercury in Different Gases." —By M. Jean Popesco.

"Molybdo-malates of Ammonium and Sodium." By M. E. Darmois.

"Action of Sodium Carbonate on Chrome Alum Solutions."—By MM. L. Meunier and P. Caste.

"Dehydration of Phenyl-1-dimethyl-2·2-butanol-1, and Diphenyl 1-3 dimethyl-2·2-propanol-1."—By Mdlle. Jeanne Apolit.

"Composition of the Essence of French Turpentine, and of the Bromide of α-Pinene."—By M. Pauselle.

"The Tetrahydronaphtols." — By MM. A. Brochet and R. Cornubert.

"Influence of Ammonium Molybdate on the

Rotatory Value of Mannite."—By M. Georges Tauret.

"Decomposition of Metallic Alcoholates and Phenates by Heat."—By M. J. F. Durand.

"Stereoscopic Photography of Crystals."—By M. Maurice François.

"Some Crystalline Rocks of Albania."—By MM. Jacques Bourcart and René Abrard.

NOTES.

Unladen Weight of Heavy Motorcars.—The General Secretary of the Commercial Motor Users' Association (Inc.) draws attention to the importance of seeing that the unladen weight which is painted on the offside of every heavy motorcar corresponds with the unladen weight as shown on the licence. Proceedings were recently taken by the police in the City of London where the weights shown on the licences were 7¼ tons and the weights on the vehicles were 5 tons, being the old registered weights. In a number of cases these proceedings were withdrawn, owing to the intervention of the Ministry of Transport at the instance of the Association. The Heavy Motorcar Order, 1904, has now been amended by increasing the maximum unladen weight of heavy motorcars to 7¼ tons, and the maximum combined unladen weight of a heavy motorcar and trailer to 9¾ tons. Users of heavy motor vehicles who desire further information are recommended to communicate with Mr. F. G. Bristow, General Secretary, Commercial Motor Users' Association (Inc.), 50, Pall Mall, London, S.W.1.

British Engineers' Association. — Although the British Engineers' Association, being a purely trade association, confines its activities to the promotion of the commercial interests of the engineering industry, and plays no part in labour disputes or wages negotiations, it is vitally interested in their effects upon output, costs of production, and selling prices. As representing the commercial side of the industry, *i.e.*, the side concerned with the profitable disposal of the products of their joint labours it may claim to speak alike in the interests of employer and employed. The present situation in the engineering trades is so grave, and the consequences to the nation threaten to be so serious, that the Council feel it their duty to present the following facts and reflections for the earnest consideration of all engaged in the engineering industry, both masters and men, and of every thinking citizen. Even before the national stoppage of work in the coal mines, a critical situation was rapidly developing in the engineering industry, because our costs of production were far too high in relation to the purchasing power of an impoverished world, in which many prospective customer countries were further restrained from buying by adverse exchanges, entailing insupportable losses. A contributory cause of our loss of trade was the ability of the United States, Germany, and Belgium to undersell us. To the extent that Germany has been able to produce and export the depreciation of her exchange has enabled her to quote prices with which the British engineering manufacturer could not possibly compete. In a lesser degree this also applies to Belgium. In spite of the strenuous efforts of directors and managers, of which we have abundant evidence, our engineering firms are quite unable to secure the volume of business required to replace the orders executed during the last six months, or now rapidly approaching completion. The fact is that although the world is in urgent need of vast supplies of products of engineering industry, to make good the losses due to the war and increase the future rate of wealth production, these supplies cannot be ordered until prices are brought within the purchasing power of the customer. This applies even to the home market, where many big schemes are being held in a state of suspense because of the prohibitive cost of carrying them into execution at present prices. To the extent that our competitors can undersell us, they will not only capture the overseas trade, but also invade our defenceless home market. It must not be imagined that the resumption of coal-mining will, by itself, revitalise the engineering industry, even though the settlement be on terms consistent with a low enough price for industrial coal. It cannot be too clearly and widely understood that the engineering industry has no chance of recovery unless and until a substantial reduction has been made in the costs of production. This is the problem to be solved, and failing its solution, other considerations will be of little more than academic interest. At some time, in the not very distant future, masters and men in the engineering trades will be compelled by the pressure of stern necessity to compose their differences and agree upon a *modus vivendi*. All their thoughts and energies will be needed for the task of salving the industry by which they live. Delay in making this great constructive effort will merely increase the amount of leeway to be painfully and laboriously recovered, and imperil the chances of ultimate success.—D. A. Bremner, Director.

Reactions of Carbon Monoxide and Iron Oxides.—Moissan demonstrated that when CO reduces ferric oxide, Fe_3O_4, FeO, and finally Fe are successively produced. The two last reactions are limited by oxidation of iron and ferrous oxide due to carbonic anhydride. M. G. Chaudron resumed these experiments, utilising a device enabling the employment of the interferential method for analysis of the gaseous mixture. The three solid phases coexist in eqnilibrinm at 580° C., and at a lower temperature the ferrous oxide gives a magnetic mixture of iron and oxide. This last transformation is reversible.—*La Nature*, March 19, 1921.

The Non-Toxicity of Copper Salts for Mildew.—Since 1886, subsequently to the work of Millardet, the employment of copper salts seemed to be essential in the composition of anticryptogamic mixtures. M. and Mme. Villedieu have already contradicted certain hypotheses hitherto accepted, regarding the formation of a hydrocarbonate which, dissolving in rain water, would give a medium where life of zoospores would be impossible. The new note demonstrates that the conidia of mildew develop, and then, in

turn, germinate in a cupric solution. The action of the mixtures hitherto employed is not then in any way due to the metal, suppression of which is to be considered in the composition of anticryptogamic mixtures.—*Comptes Rendus*, Feb. 7, 1921.

A NEW organisation, under the title of The *Federation of British Propaganda Societies* has been formed, the object of which is to co-ordinate the work of propaganda societies and, as far as possible, prevent overlapping. Already about 15 propaganda societies have expressed their willingness to join. His Grace The Duke of Northumberland has consented to act as President, and Sir Henry Birchenough, K.G.M.G., is the Treasurer. The General Secretary is Mr. David Gilmour, O.B.E., Sicilian House, Southampton Row, London, who will be willing to give further information to any of our readers.

OUTPUT OF BROMINE IN U.S.A. IN 1920.—The New York *Journal of Commerce* states that bromine, which is derived from brines pumped from deep wells in Michigan, Ohio, and West Virginia, was produced by eight firms in the United States in 1920. The output, according to the United States Geological Survey, Department of the Interior, was 1,160,584lb., valued at $745,381, a decrease of 37 per cent in quantity, and nearly 40 per cent in value from the output of 1919. The quantity produced, however, was greater than in any year before 1918. The average price per pound received by the producers rose from 13 cents in 1910 to $1·31 in 1916, and was 64 cents in 1920, which is more than three times the average price in the year before the war. The New York quotations on bulk bromine, which ranged from 70 to 90 cents in the summer of 1920, were 50 to 52 cents in December, and are now about 40 cents.—*Department of Overseas Trade*.

AN INDUSTRIAL OPTIMIST.—Mr. H. G. Williams, M.Sc., a member of the Industrial League and Council seems to be an optimist of the first water. Months ago he was predicting what at the time seemed an impossible fall in the cost of living, but events have substantiated his assertion, and now he is equally emphatic on the point of a trade revival. With the nation still in the throes of countless industrial differences, on the verge of maturing to formidable dimensions, one must, indeed, be sound of heart to acquiesce with him in his optimism. Yet, so accurate has Mr. Williams been in his prognostications heretofore, that he may infuse a degree of confidence where pessimism prevails. It was towards the close of January this year that he wrote: "By May, retail prices should be about a fifth lower than they were on November 1st, 1920, and the cost of living should then be about 120 per cent above pre-war level. I venture to predict that by the end of the summer the level will have fallen to about double pre-war prices, *i.e.*, 100 per cent." Were it not for the coal dispute, there is not the slightest doubt that the index figures for the cost of living published on May 1 would have been well below the prophetic figure of 120 cited by Mr. Williams, instead of standing at 128. How near he will prove to be accurate in his contention that the cost of living will be down to 100 per cent by the close of the summer remains to be seen. In the current issue of the *Industrial League Journal* he says: "The world-wide indications at the moment show the beginning of a general revival of commercial confidence. A world revival in trade may be predicted with considerable certainty, and this country will share in that revival provided that British goods can be offered at prices sufficiently attractive. This will probably involve employers and employed making adjustments in their minds as to the money value of the profits and wages which they can reasonably expect to obtain, but even more important is the increase in individual production which will ensure lower selling prices without the necessity of any serious lowering of the standard of living, though, temporarily, both employers and employed may find themselves forced to accept a lower standard than they have enjoyed in the recent past." Mr. Williams has on more than one occasion voiced the opinion that it will not be long ere the cost of living will be down to 75 per cent above the pre-war figure. It seems like anticipating the millenium.

THE POLISH POTASH INDUSTRY.—It is quite probable, when the frontiers of New Poland are definitely fixed, that the districts of Steppenitz and Kalusz, comprising deposits of salt and potash, in East Galicia, will be allotted to this country. Hitherto potash has only been mined at Kalusz, the deposit being industrially workable, in the opinion of experts. The Kalusz deposits contain chlorides and sulphates of potassium and magnesium, and the upper bed sylvinite and kainite. The bed of kainite is 10 to 12 metres thick, and in some places 17. There are four distinct beds of potash. The sylvinite bed is about two metres thick, and contains 25 to 60 per cent of potassium chloride. The second bed is 1·5 metres thick, and has 12 per cent potassium chloride, being situated 30 metres below the kainite deposit. Below the chief deposit there is a third sylvinite deposit, consisting of two beds, containing 42 per cent potassium chloride, 12 to 80 metres thick. It is not very probable that the potash mines of East Galicia will be of great importance to foreign markets, and the Kalusz mines can only be of local importance.—*Chimie et Industrie*, May, 1921.

NEW COMPANIES.

The under-mentioned particulars of New Companies recently registered are taken from the *Daily Register* compiled by JORDAN & SONS, LIMITED, Company Registration Agents, Chancery Lane, W.C.2.

CLIMAX MANUFACTURING COMPANY, LIMITED.—(175211)—Registered 15th June, 1921. 283, Victoria Dock Road, West Ham, Essex. To carry on the business of Chemists and Druggists. Nominal Capital: £1,200 in 1,200 Shares of £1 each. Directors: A. Curtis, Groveley, Feltham Hill, Middlesex; D. Cable, 5, Avondale Road, Mottingham, Kent; S. J. Coxwell, Milton Lodge, First Avenue, Westcliff-on-Sea. Qualification of Directors: £100. Remuneration of Directors: To be voted by Company.

KLEANEESE SOAP COMPANY, LIMITED.—(175219)—Registered 15th June, 1921. 47, Church Street, Stoke Newington, N.16. To acquire and carry on the business of Soap and Polish Manufacturers. Nominal Capital: £500 in 1,000 Shares of 10/- each. Directors: P. H. Bateman, 23, Vesta Road, Brockley, S.E.24.; G. Hartrodt, 120, Greenwood Road, Hackney, E.8.; D. Bailey, Beechwood, Moss Lane, Pinner. Qualification of Directors: 1 Share. Remuneration of Directors: To be voted by Company.

New Patents.

THIS List is specially compiled for the *Chemical News* by Messrs. Rayner & Co, Registered Patent Agents, of 5, Chancery Lane, London, W.C.2., from whom all information relating to Patents, Trade Marks and Designs can be obtained gratuitously.

Latest Patent Applications.

15732—Badische Anilin & Soda Fabrik.—Production of oxalic acid. June 7.

15815—Chemical & Metallurgical Corporation, Ltd.—Treatment of argentiferous lead zinc sulphide ores. June 8.

16148—Craig, E. N.—Electrolytic treatment of metalliferous materials containing tungsten or molybdenum. June 11.

15931—Dreyfus, H.—Treatment of products of cellulose derivatives. June 9.

16159—Liebreich, E.—Process for separating-out metallic chromium. June 11.

Specification published this Week.

164034—Cocking, A. T. and Lilly, C. H.—Production of glycerine by fermentation.

Abstract Published this Week.

Treating Lead-Zinc Ores.—Mr. E. P. Elmore of Boxmoor, Hertfordshire, has obtained a Patent No. 162026 for a process of treating argentiferous lead-zinc sulphide ores. They are roasted with a halogen salt such as sodium, potassium, calcium, or magnesium chloride in an oxidizing atmosphere at a temperature above 400°C. but not high enough to volatilize lead chloride, but zinc sulphide remaining for the most part unattacked. To prevent any appreciable attack on the zinc the temperature should not exceed 500°C., The air employed in the roasting is preferably moistened if dry. The product of the roasting is leached with hot brine to extract lead, some silver and any zinc chloride. The lead and silver are recovered in any known manner, for instance, by cooling the solution and treating the deposited chlorides as described in Specification 129773 to separate the silver as argentiferous lead sulphate, the brine being used repeatedly. The residual ore is treated with a solvent for silver such as a solution containing 35 per cent calcium chloride and 3-5 per cent cupric chloride or 3 per cent hydrochloric acid as described in Specification 151698 or, if there is an appreciable quantity of lead, the ore is first treated with hot brine containing hydrochloric or sulphuric acid as described in Specification 127641 to extract the lead and part of the remaining silver, and then as above described to extract the remaining silver. The used brine containing sodium sulphate and the lead salts obtained may be treated as described in Specification 129773 to de-sulphate the brine and obtain lead sulphate. In a modification if there is some unoxidized lead sulphide remaining after the roasting or after the leaching with brine, the ore is leached with hot strong solution of calcium or magnesium chloride containing enough hydrochloric acid to convert the lead sulphide into chloride. This effects a good extraction of the silver and renders a subsequent extraction unnecessary. If it is preferred to have a small quantity of zinc chloride present in the calcination, which may be derived from the ore if it contains some easily attackable zinc, or, may be added at the beginning or towards the end of the calcination, preferably as a mixture of sodium and zinc chlorides obtained by evaporating some of the brine used for leachings. Specifications 131353, 135968 and 141044 also are referred to.

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NOTICES.

EDITORIAL.—All Literary communications and Books, Chemical Apparatus, &c., for review or notice to be addressed to the EDITOR.

SUBSCRIPTIONS, £1 12s. per annum, payable in advance, should be addressed to the MANAGER.

BACK NUMBERS and VOLUMES can be purchased on application to he MANAGER.

THE CHEMICAL NEWS,

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ADVERTISEMENTS.

All communications for this Department should be addressed to—

T. G. SCOTT & SON,

63, LUDGATE HILL, LONDON, E C.4.

STAFFORDSHIRE EDUCATION COMMITTEE.

APPLICATIONS are invited for the post of PRINCIPAL and HEAD of the METALLURGICAL DEPARTMENT of the COUNTY TECHNICAL COLLEGE, WEDNESBURY, (in succession to Mr. Walter Macfarlane, F.I.C.), at a salary of £600. The person appointed must be a competent metallurgist with good academic qualifications; practical experience in works is essential.

Further particulars and forms of application, which must be returned before 8th July, may be obtained from the undersigned.

GRAHAM BALFOUR,
Director of Education.

County Education Offices,
Stafford.
June, 1921.

UNIVERSITY OF ABERDEEN.

LECTURER IN CHEMISTRY.

APPLICATIONS are invited for the post of Lecturer in Chemistry. Salary £435 per annum. Candidates should have special attainments in Organic Chemistry. Applications, together with a full statement of qualifications and the names of two references, *should be sent not later than TUESDAY* 5th JULY, to the undersigned, from whom further particulars may be obtained.

H. J. BUTCHART,
Secretary of the University

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1- AUG 1921

THE CHEMICAL NEWS
VOL. CXXIII., No. 3195.

WHITLEYISM THE ONLY SOLUTION.

CONSIDERED VIEWS OF THE INDUSTRIAL LEAGUE AND COUNCIL.

WE have received the following memorandum from the Industrial League and Council:

The extremely critical position into which Industry has now drifted gives cause for the gravest anxiety. Disputes of a national and local character have created a feeling of instability to all concerned. Confidence, the bed-rock of trade and commerce, must be restored to the world. Industry is almost at a standstill, and our foreign trade, both imports and exports, shows an alarming decrease. The Industrial League and Council have given this matter very serious consideration, and are convinced that no permanent or substantial change will occur until there exists a greater confidence between employers and employed. The development of Labour and Employer organisations on antagonistic lines places the two bodies in opposing camps from which they tend to view each other with hostility. From circumstances such as these it is hardly possible for anything to accrue hut disputes, strikes, and lock-outs.

The formation of a National Joint Industrial Council would not, in the opinion of the Industrial League and Council, do much to lessen the tension existing. Rather would it add to the difficulties, as a National Joint Industrial Council, whilst it would be useful for the exchange of opinons, would be too unwieldy and complex to be of any use as a means for industrial harmony. As an alternative, the Industrial League and Council advocates strongly the formation of Joint Industrial Councils in every industry as the only means whereby disruption in industry may be avoided; 70 of these have already been established, most of which have been very successful.

The world is suffering from a complete shortage of almost, if not all, the necessaries of life, and only years of hard work and sacrifice on the part of all, whether employers or empolyed, will in any way remedy the circumstances. The warlike policy which still unhappily characterises our industrial relations can lead to nothing but disaster for the whole community. Lost foreign markets are extremely difficult to re-establish, and lost time caused by industrial disputes is an important factor in maintaining high prices. The recent mining dispute has lost to the miners at least £55,000,000 in wages; it has lost to Industry countless millions of pounds sterling. Joint Councils of Employers and Employed in the mining, as in other industries, would, in the opinion of the Industrial League and Council, minimise the possibility of disputes, and would bring harmony and prosperity to the industry. The total number of workpeople involved in disputes during the last 12 months is 5,414,000, and the total working time lost is 72,885,000 working days; these are independent of the vast body of workers who were otherwise out of employment, of whom no less than nearly 8 millions drew unemployed pay during the same period. Time and labour lost is a reduction in national wealth and affects every member of the community.

The Industrial League has from its inception in 1915 resolutely abstained from any interference in trade disputes. It has consistently advocated the better relations a s between employer and employed, and has since 1917 assisted in establishing Whitley Councils. It is strongly of opinion that the time has arrived when every industry, no matter how well organised it may be on either side, should have its Joint Industrial Council.

Amongst the signatories to the memorandum are the following members of the Executive Committee of the Industrial League and Council: Viscount Burnham, C.H., Rt. Hon. G. H. Roberts, M.P., Sir Wm. Peake Mason, Bart., Mr. John Baker (Iron and Steel Trades Confed.), Mr. E. J. P. Benn, C.B.E., Mr. A. Bellamy (Ex-President N.U.R.), Mr. Hugo Hirst (General Electric Co.), Mr. E. W. Petter (Messrs. Vickers Petter, Ltd.), Mr. Robt. Young, M.P.

Events of the past week strikingly illustrate the fact that if anything will bring this country back to a state of productivity and place our industries in a position to successfully compete in all the markets of the world, it is the practical appreciation of the principles of Whitleyism. In this respect facts substantiate the views expressed by the Industrial League and Council.

For instance, in the wool textile industry, peace for at least a year has been accomplished by the satisfactory manner in which the National Wool (Allied) Textile Industrial Council on Monday the 27th ult., came to agreement on a different wage question.

A similar report comes to hand in respect of the flour milling industry, the operation of which directly effects every person in the land. On Wednesday, the 29th ult., a wage cut of 7s. 6d. per week was agreed upon by the National Joint Industrial Council for this industry.

The railways have embraced Whitleyism; the printers, by reason of its operations have been without serious strife for a long period, and are at this moment amicably discussing a proposed wage reduction. Farm workers are anxious to obtain a Whitley Council because they appreciate its value, and this week also, the dockers are discussing at the Board of their National Joint Council for the Docks the all-absorbing wage question, and will, no doubt, arrive at a solution of their difficulties without strife. These are but few of the happenings in the world of Whitleyism tending to shape the future welfare of our people. These Councils have been working steadily and unobtrusively for months past, and it is only on rare occasions they figure in the limelight, and then only because all sections engaged in an industry are unable to see eye and eye on a particular matter.

SOIL ACIDITY IN ITS PHYSICO-CHEMICAL ASPECTS.*

By E. M. CROWTHER, Rothamsted Experimental Station.

THE application of basic materials, such as lime or chalk, has long been known to result in increased soil fertility, especially in the case of the so-called "sour soils." Such soils are recognised in practice by a fairly characteristic weed flora

*A Contribution to a General Discussion on "Physico-Chemical Problems Relating to the Soil" held by The Faraday Society, on Tuesday, May 31, 1921.

the failure of leguminous crops, and the liability of cruciferous crops to certain fungoid diseases. Sour soils redden blue litmus paper when it is pressed on to the moist soil, so that the obvious view was avanced that the infertility is due to the presence of acids, which are neutralised by the application of lime. Methods for the determination of the amount of this acidity and therefore of the "lime requirement" of the soil, were devised on the assumption that the interaction between a sour soil and a base was a simple neutralisation. (Examples of such methods are the Veitch method involving the addition of lime water in slight excess, and the Hutchinson-McLennan method in which the $CoCO_3$ removed from a calcium bicarbonate solution is estimated).

A second group of methods depended on the curious fact that sour soils set free considerable amounts of titratable acid from salt solutions such as KCl or $KC_2H_3O_2$.

A large amount of work has been devoted to the investigation of the validity of these lime requirement methods. Several of them have provided quite useful practical information, but their application is circumscribed by the fact that it is only on comparable soils that the "lime requirements" adequately represent the response to limeing. Further, all the methods are very sensitive to slight variation in technique, and different methods give widely divergent results when applied to the same soil. In a recent study of the Hutchinson-McLennan method, Fisher has shown that the amount of $CaCO_3$ removed from solution is not independent of the concentration of the bicarbonate used, but that the distribution of $CaCO_3$ beween soil and solution may be represented by the usual adsorption equation. The taking-up of base by a sour soil appears to involve not only the simple neutralisation of acids, but also some absorptive process by the soil colloids.

Many workers have attached more importance to the absorption than to the presence of acids. It has been held that in fertile soils, well provided with reserves of $CaCO_3$, the absorptive power of the soil colloids for bases is fully satisfied, but that the continuous removal of the basic material by plant growth and drainage may result ultimately in a colloidal system with a marked affinity for bases. Ramann therefore replaced the term "acid" as applied to soils by "adsorptively unsaturated." Baumann and Sully, working with peat soils, and Cameron and Harris with mineral soils, denied the existence of acids in soils giving aqueous neutral to litmus paper. Selective adsorption of bases was held to account not only for the action of litmus paper and for the liberation of acid from salt solutions, but for the large variations in the amounts of different bases taken up by the soil from alkaline or neutral solutions. The possibility of establishing the existence of acids in the soil by titration was the subject of prolonged controversy. Truog, for example, maintained that by using diluted solutions to reduce side-reactions, equivalent amounts of NaOH, $Ca(OH)_2$, and $Ba(OH)_2$ were neutralised by sour soils.

The Measurement of the H·-Concentration of Soils.

The lime requirement methods were intended to measure the "quantity factor" of acidity, *i.e.,* the total amount of acid as measured by titration. But the acid properties of a solution can onl expressed by the *"intensity factor," i.e.,* the hy gen ion concentration (or activity). Many soils have been shown to possess a H·-concen tion considerably greater than that of water, that there is now no valid reason for denying existence of acid substances in sour soils.

The use of the hydrogen electrode is practica in complex mixtures only if they possess c siderable buffer action, *i.e.,* some mechanism maintaining an almost unchanged reaction on addition of small quantities of acid or alk Aqueous extracts of soils are but feebly buffere the introduction of a little alkali, such as t ammonia produced by the reduction of nitrates the hydrogen electrode, causes considerable alte tion in reaction. Suspensions of soil in wat however, are strongly buffered, and give qu definite results with the hydrogen electrode. very wide range of H·-concentrations has been corded; thus Gillespie found values for $-\log$ [I or pH from 4·4 to 8·6. Sharp and Hoagland w a somewhat less satisfactory technique found range of 3·7 to 9·3, though the fertile soils amined by them showed very similar values, va ing from the neutral point to about 7·5 on t alkaline side.

The potential difference which forms the ba of the method can be measured with a high deg of accuracy, but with soils difficulties are int duced by the necessity of working with susp sions. Measurements cannot be made soils at their natural water or CO_2 contents. well-buffered mixtures, dilution produces lit alteration in reaction, and it has been found th variation in the soil-water ratios or the additi of moderate quantities of CO_2 to the hydrog used, produces but little alteration in the resu obtained. It is therefore generally assumed th the values obtained aproximate to those of t soil solution.

The sulphone phthalein indicators of Clark a Luhs have been used for the determination of t H·-concentration of aqueous soil extracts, and, the only comparison hitherto made with the r sults for soil suspensions by the hydrogen ele trode, Gillespie has obtained very satisfacto agreement. This is especially important becau the most probable sources of error in the tw methods arise from different causes. The princ pal difficulty involved is the preparation of suf ciently clear soil extracts for colour matchin Prolonged centrifuging is often insufficient a it is then necessary to resort to dilution, sin filtration or flocculation often produces qui marked changes in such weakly buffered solution

Considerable importance has been attached the past to the differences towards litmus pap exhibited by the moist soil and the soil extrac An insensitive indicator such as litmus, especial on paper, requires an appreciable amount of ac to effect the change to red. With small quan ties of weakly buffered solutions, such as soil e tracts or very dilute HCl, the reaction of th liquid may be seriously changed, whilst if a larg bulk of solution be left in contact with the litmu leaching may occur before the correct tint reached. When the paper is pressed on to th moist soil, the proximity of the soil allows rapi diffusion of acid to the paper, whilst its reactio is changing, and a fair indication of the soil r action may be obtained.

The mechanism of buffer action in the case of partially neutralised weak acids is easily explained in terms of the dissonation constant, but it is not generally possible to analyse the factors involved in more complex systems. The difficulties of technique have prevented much work on the determination of the changes in $-\log [H^{\cdot}]$ during the titration of acid soils with bases, but it has been found that the soils are well-buffered over considerable ranges of $H^{\cdot}$-concentration. In other words, the titration curves showing $-\log [H^{\cdot}]$ as a function of the amount of base added are practically linear without any sharp breaks corresponding to "end points." The slopes of the curves vary considerably from soil to soil, so that it is possible for a strongly acid soil to possess little titratable acidity or a low lime requirement, whilst neutral or even slightly alkaline soils may show an appreciable requirement if the soil be brought into equilibrium with an alkaline solution.

Action of Neutral Salts on Acid Soils.

Sharp and Hoagland have shown that $BaCl_2$, KCl, or NaCl increase the $H^{\cdot}$-concentration of suspensions of acid soils. In a more detailed study of the action of salts on humus suspensions Gillespie found that the same action occurs and that the increases produced by different chlorides are in the order Ba>Na>K. The interpretation of these results is complicated by the fact that these salts produce similar, though smaller, increases in the $H^{\cdot}$-concentration (or activity) of true solutions.

The increase in $H^{\cdot}$-concentration is accompanied by considerable amounts of titratable acid, the estimation of which was used in some of the early lime requirement methods. In spite of much investigation, the interpretation of this action is still obscure. On the selective adsorption theory the action is regarded as strictly analogous to the the liberation of acid and fixing of base during the precipitation of colloidal solutions of As_2S_3 by $BaCl_2$. The importance attached to the adsorption of cations for the coagulation of negative colloids gave some support to this view, but no clear mechanism was advanced to explain the liberation of acid.

Neutral salt extracts of acid soils contain weak bases—chiefly Al, though Fe, Mn or even Zn are sometimes found—in amounts roughly equivalent to the titratable acidity. Parker modified the selective adsorption view by assuming that the salt is hydrolysed, the base being adsorbed whilst the acid dissolves the weak hases from the soil. Others regard the aluminium salts as the cause rather than the result of the acidity of the neutral salt extracts. Rice found that the relations between the $H^{\cdot}$-concentration and titratable acid of KNO_3 extracts corresponded closely with those of mixtures of $Al(NO_3)_3$ and KNO_3, and concluded that the amount of aluminium was precisely equivalent to the titratable acid, the apparent exceptions arising from the difficulties of analysis and titration. Rice and Daikuhara regard this basic exchange as taking place with loose adsorption compounds of weak bases which characterise acid soils, whilst Veitch and later workers hold that the interaction occurs with the complex alumina-silicates of the soil. Whatever the mechanism of this basic exchange, the differences in the hydrolysis and solubilities of the various salts concerned will account for many of the results. The excess of a salt of a weak acid prevents any considerable rise in $H^{\cdot}$-concentration, so that the aluminium salts are almost completely hydrolysed and precipitated with the liberation of much-titratable acid, whilst with salts of strong acids higher $H^{\cdot}$-concentrations occur, so that the Al remains in solution and the reaction soon reaches an equilibrium point. Similar reactions of the aluminates and silicates of Ca or K will account for the greater adsorption of Ca during the action of the hydroxides on sour soils. In the case of peat soils Sven Odén suggests that the acidity of salt extracts arises from the displacement of small amounts of organic acids adsorbed by humus. He found no HCl by distillation of a KCl extract of an acid peat, and an aqueous extract of the treated peat was not alkaline, so that there was no evidence of any hydrolytic decomposition by adsorption.

The complexity of the soil system is such that nothing is to be gained at present by formulating any general theory of the origin and nature of soil acidity.

Relation of Soil Acidity to Plant Growth.

Until recently soil acidity has been regarded as a pathological condition to be avoided by liming, but the reaction of the soil may vary within fairly wide limits and it does not follow that $-\log (H^{\cdot})=7{\cdot}07$ is the optimum for plant growth. Soil fertility is the resultant of the interaction of a large number of factors on the plant, and these factors are likely to be influenced to different degrees by the reaction of the soil solution. There is evidence that a distinctly acid reaction may be desirable for certain crops, and attempts are being made in New Jersey to increase the acidity of potato soils by the production of H_2SO_4 through the oxidation of sulphur added to the soil.

The reaction of acid soils is frequently of the same order as that of plant roots, so that the infertility of most acid soils would not appear to be due to the direct action of the acid on the roots. Of the indirect effects Truog attaches the greatest importance to the lack of available basic material, such as $CaCO_3$, for the neutralisation of the acids produced in the plant, whilst several workers have ascribed the infertility to the toxic action of aluminium compounds. Gillespie has recently made some preliminary measurements of the reduction potentials of water-logged soils, and has suggested that the "sourness" of poorly drained soils may be the result of their high reducing power.

An extensive bibliography of soil acidity i given by E. A. Fisher, *Journal of Agric. Science* 1921, xi., 19.

THE CLINTON WATER SUPPLY AND THE MISSISSIPPI RIVER.

By RUSSELL MORGAN.

THE water supply of Clinton, Iowa, situated o the Mississippi River, comes from a series of fiv wells located above the city. The wells ar 200ft. to 250ft. from the river, and from 1800ft. t 2200ft. in depth. The numbers here given expres the amounts of the various substances in a millio parts of the water.

Total solid residue	251·8
SiO_2	1·0
Fe_2O_3 and Al_2O_3	1·60
$CaCO_3$	54·60
$CaSO_4$	52·10
$MgCO_3$	27·40
NaCl and KCl	116·00
Phosphates	0·0
Nitrite nitrogen	0·0
Nitrate nitrogen	0·1
Free ammonia	0·015
Albuminoid ammonia	0·06

The Water from the Mississippi.—The sample was taken from about the middle of the stream. The water was slightly cloudy, so we filtered it through a paper.

Total solid residue	219·2
SiO_2	13·8
Fe_2O_3 and Al_2O_3	2·0
$CaCO_3$	66·40
$MgCO_3$	48·90
$CaSO_4$	17·50
NaCl and KCl	69·80
Nitrate nitrogen	1·10
Nitrite nitrogen	0·008
Carbon dioxide	93·00
Free ammonia	0·04
Albuminoid ammonia	0·48

The Unfiltered Water from the River.

Total residue	259·0
SiO_2	33·20
Fe_2O_3 and Al_2O_3	2·6
$CaCO_3$	94·10
$CaSO_4$	17·50
$MgCO_3$	48·60
NaCl and KCl	69·80

The cloudiness of the unfiltered river water seems to be due to a small quantity of silica and calcium carbonate in suspension.

The river water and well water contain a relatively large amount of chlorides, and the waters in most other respects are quite similar. Both are rather soft waters for this section of the country, where there is an abundance of dolomite rock. Although the wells are encased, there is a possible connection between the river and the wells.

Cornell College, Mount Vernon, Iowa.
June 4, 1921.

AN EXTRAORDINARY NUMERICAL RELATIONSHIP BETWEEN CALCIUM AND STRONTIUM.

By ALEXANDER SAKOSCHANSKY, B.Sc.

It has been frequently stated that atomic weight numbers are something more than relative numbers. While with the present system numerical relationship of a simple type exists only with a few elements, such as $\sqrt{2 \cdot 43} = 15588$, $23^2 = 529$, $3912^2 = 1529$, a system based on other numbers would place other elements in a numerical relationship.

The following is of particular interest, because the values have been derived in a systematic manner. If 0·11063 ($\log_{10}$. 1·290) be used as a multiplicand for atomic weights, it will give several pairs of corresponding values, *e.g.*,

Selenium × 11063 = Strontium
Sulphur × 11063 = Chlorine.

There are no other multiplicands which are as effective. Another way of expressing this relationship is $\frac{35 \cdot 46}{25 \cdot 46} \times 2 \cdot 30258 = 3 \cdot 207$, since 0·2546 is $\log_e$ 1·290, and 2·30258 is the conversion factor from *e* to 10. (Note.—By analogy:—

$$Zn = \frac{65 \cdot 394}{55 \cdot 394} \times k = 2 \cdot 7183;\ Mg = \frac{24 \cdot 32}{14 \cdot 32} \times k = 3 \cdot 913).$$

Obtaining a system of atomic weights, chlorine = 25·46, Ca = 28·784, Sr = 62·918 (H = 0·7180).

$$(1) \qquad \frac{28 \cdot 784}{18 \cdot 784} \times k = 3 \cdot 5284$$

$$(2) \qquad \frac{62 \cdot 918}{52 \cdot 918} \times k = \underline{2 \cdot 7377}$$

$$\text{Now } \log_{10} \underline{1 \cdot 8784} = 0 \cdot 27379$$

$$\text{and } \frac{\log_{10} 3 \cdot 5284}{2} = \underline{0 \cdot 27379}$$

$$\text{or } \sqrt[2]{\underline{3 \cdot 5284}} = \underline{1 \cdot 8784}$$

Barium shows an interesting numerical relationship which cannot be described in this short article.

In addition it should be noted that on the basis *Cl* = 25·46, fluorine and iodine are in logarithmic decrement, for F = 13·64, I = 91·12, $10 \times 1/F = \log_x I$, x = anti-$\log_{10}$ 1·365 = 1·352. Magnesium = 17·46.

A STUDY OF ARSENICAL COMPOUNDS RELATED TO ARSPHENAMINE.

By GEORGE W. RAIZISS and JOSEPH L. GAVRON.

Introduction.

Experiences of the last decade have shown to the leading syphilologists that arsphenamine, which is the official American name for 3,3'-diamino-4,4'-dihydroxy-arsenobenzene dihydrochloride (P. Ehrlich and A. Bertheim, *Ber.*, 1912, xlv., 756), is one of the most efficient remedies in the treatment of syphilis. It has been observed by many that intravenous injections of this drug sometimes produce alarming symptoms. While these have been attributed to various causes, some relating to the condition of the patient, and others relating to he technic of adminisration, it seemed very probable to us that chemical impurities in arsphenamine may produce the disturbing effects. Therefore, we deemed it advisable to prepare a number of compounds, which are closely allied to arsphenamine and which might appear as impurities in the drug in the course of manufacture.

Arsphenamine is produced by the reduction of 3-nitro-4-hydroxy-phenylarsinic acid which sometimes contains the corresponding dinitro derivative as an impurity. It is possible, therefore, that arsphenamine may be contaminated with 3,5,3',5'-tetra-amino-4,4'-dihydroxy-arseno-benzene tetrahydrochloride. In view of this fact, it was of interest to prepare the latter compound and study its chemical and biological properties (J. F. Schamberg, G. W. Raiziss, J. A. Kolmer, and J. L. Gavron: "The Chemotherapy of Arsenical Compounds Related to Arsphenamine" (to be published

later). We observed also that it exerts a curative influence upon trypanosome infections, hence the preparation and study of derivatives of the above tetra-amino compound suggested themselves.

In the course of this work it was observed that an increase in the number of amino groups decreases the stabilty of both the phenylarsinic acids and the arsenobenzenes. On the other hand, the solubilities of the corresponding hydrochlorides in water are increased.

3,5-*Diamino-4-hydroxy-phenylarsinic Acid.*—This compound has been very briefly mentioned in a German patent (*D. R. P.*, 224,953, 1910), in which the method of preparation consists of the reduction of 3,5-dinitro-4-hydroxy-phenyl-arsinic acid by means of sodium hydrosulphite. The same compound has been prepared by us according to the following procedure.

Twenty g. of 3,5-dinitro-4-hydroxy-phenylarsinic acid is suspended in 50 cc. of water and dissolved by adding 13 cc. of 40 per cent sodium hydroxide (2 mols.). To this solution is added a solution of 40 g. of magnesium chloride (crystals) in 400 cc. of water, the whole cooled down to 0° and reduction effected by gradually introducing 130 g. of sodium hydrosulphite (commercial powder) with continuous mechanical stirring. During this process, the temperature should not be permitted to rise above 2°, since otherwise further reduction to the arseno compound will occur. When all the hydrosulphite has been introduced, the solution becomes decolorised, and upon continued stirring for 1·5 hours at 0° a white crystalline precipitate of the amino compound appears. This is filtered off and the mother liquor expressed as completely as possible. To purify, the crude product is dissolved by triturating with an excess of diluted hydrochloric acid in a mortar. The solution is filtered, and the filtrate neutralised at low temperature witb concentrated sodium hydroxide solution until it is but slightly acid to congo red paper. The precipitate of the pure amino compound is filtered off and washed with cold water until it is free from sulphate and chloride, then with methyl alcohol, and finally with ether. It is dried *in vacuo* over sulphuric acid. The yield (after one purification) is about 8·0 g. or 50 per cent.

Properties. — 3,5-diamino-4-hydroxy-phenylarsinic acid is a white crystalline product which darkens during the process of purification. It is soluble in alkalies, also hydrochloric acid: insoluble in methyl alcohol, ethyl alcohol, ether, acetone, chloroform, benzene. Its solution in alkali darkens very rapidly on standing exposed to the air.

Calculated for $C_6H_7O_4N_2As$: N, 11·29; As, 30·24. Found: N, 10·70; As, 29·52.

3-*Amino-4-hydroxy-phenylarsinic Acid.* — This compound was first prepared by Ehrlich and Bertheim by the reduction of 3-nitro-4-hydroxy-phenylarsinic acid with sodium amalgam (*D.R.P.*, 224,953, 1910). Another method in which sodium hydrosulphite is used as the reducing agent has been briefly described in a German patent (*D.R.P.*, 224,953, 1910). Jacobs and Heidelberger (*Jour. Am. Chem. Soc.*, 1918, xl., 1580) prepared this same arsinic acid by the use of ferrous sulphate and sodium hydroxide. The authors in preparing this compound used sodium hydrosulphite as the reducing agent.

Twenty g. of 3-nitro-4-hydroxy-phenylarsinic acid is suspended in 50 cc. of water and dissolved by adding 15 cc. of 40 per cent sodium hydroxide solution (2 mols.). A solution of 40 g. of magnesium chloride crystals in 300 cc. of water is added, the whole cooled down to 0°, and reduced by adding 85 g. of sodium hydrosulphite and proceeding exactly as in the case of the previous compound. The yield of purified product is about 10·8 g. or 61 per cent.

Properties.—3-Amino-4-hydroxy-phenylarsinic is a white crystalline substance which during purification turns slightly brown. It is soluble in hydrochloric acid, sodium and ammonium hydroxides; insoluble in acetic acid and the usual organic solvents. Its alkaline solution darkens rapidly on standing in air.

Calculated for $C_6H_8O_4NAs$: N, 6·01. Found: 5·74

Acetyl-3-amino-4-hydroxy-phenylarsinic Acid.—Ten g. of 3-amino-4-hydroxy-phenylarsinic acid is suspended in 50 cc. of water, immersed in an ice bath, and mechanically stirred. Nine cc. of acetic anhydride (one mol equals 4·4 cc.) is gradually introduced, and the stirring maintained for three hours. The whole is filtered, and the precipitate suspended in dilute hydrochloric acid. This removes the unchanged amino compound, the acetyl derivative remaining undissolved. This is filtered off, washed with water till free from hydrochloric acid, then with methyl alcohol, and finally ether. It is dried *in vacuo* over sulphuric acid. The yield is 3·5 g. of pure substance.

Properties.—Acetyl-3-amino-4-hydroxy-phenylarsinic acid is a light brown crystalline substance soluble in dilute alkalies. It is insoluble in hydrochloric acid, acetic acid and the usual organic solvents.

Calculated for $C_8H_{10}O_5NAs$: N, 5·09; As, 27·27
Found: N, 5·10; As, 27·61.

Diacetyl-3,5-Diamino-4-hydroxy-phenylarsinic Acid.—This compound is prepared from 3,5-diamino-4-hydroxy-phenylarsinic acid in exactly the same way as the previously described compound. The yield is 75 per cent.

Properties.—A pale brown crystalline substance soluble in sodium and ammonium hydroxides. Insoluble in water, hydrochloric acid, and the usual organic solvents.

Calculated for $C_{10}H_{13}N_2O_6As$: N, 8·43; As, 22·6
Found: N, 8·49; As, 22·98 per cent.

3,5,3',5'-*Tetra-amino-4,4'-dihydroxy-arsenobenzene Tetrahydrochloride.*—Although this amino componnd has been very briefly described in a German patent, its tetrahydrochloride has not been described. It is interesting to note that it appears to exist in two modifications, one easily soluble in methyl alcohol, and the other only sparingly so.

25 g. of the corresponding dinitro-hydroxy phenylarsinic acid is dissolved in 525 cc. of water to which has been added 16 cc. of 40 per cent sodium hydroxide solution (2 mols.). Reduction is effected by a solution of 575 g. of sodium hydrosulphite and 65 g. of magnesium chloride in 2600 cc. of water. After 1·5 hours' stirring at 55° to 60° the yellow precipitate of the tetra-amino compound is filtered, washed with distilled water until most of the hydrosulphite has been removed and then dried on porous plates.

To convert the dried base into its tetrahydrochloride, it is introduced into 220 cc. of absolute

methyl alcohol containing hydrogen chloride. About one-half of the tetrahydrochloride dissolves. This is decanted off. The remaining insoluble portion is triturated in a mortar with more ethyl alcohol-hydrochloric acid solution in order to remove the soluble fraction completely. The entire methyl alcohol solution of the tetrahydrochloride is mixed with five volumes of U. S. P. ether. A light yellow precipitate is immediately produced. This is allowed to settle, the supernatant fluid decanted, the precipitate washed several times by decantation with ether, rapidly filtered and finally dried *in vacuo* over sulphuric acid. The yield is 8·0 g.

The undissolved fraction of the tetrahydrochloride is washed with ether and also dried *in vacuo* over sulphuric acid. The yield is 7·5 g.

Both modifications are yellow substances easily soluble in cold water From this solution the base is precipitated by the addition of sodium hydroxide and redissolved when sufficient alkali has been added to form the monosodium salt. This solution on standing rapidly becomes turbid due to the action of the carbon dioxide of the air. A solution of disodium salt is less readily precipitated. Both salts in solution when exposed to the air, rapidly oxidise, more so than the corresponding salts of 3,3′-diamino-4,4′-dihydroxy-arsenobenzene dihydrochloride.

Analysis.—Neutralisation of the hydrochloride and formation of monosodium salt. Soluble modification: subs., 0·100: 9·0 cc. 0·1 *N* NaOH Insoluble modification: subs., 0·100: 7·5 cc. 0·1 *N* NaOH. Calculated for $C_{12}H_{18}N_4Cl_4O_2As_2.1CH_3OH$: 8·7 cc. 0·1 *N* NaOH.

Oxidation by iodine.

Soluble modification. Subs., 0·100: 13·50 cc. 0·1 *N* iodine.

Insoluble modification. Subs., 0·100: 13·6 cc. 0·1 *N* iodine.

Calculated for $C_{12}H_{18}N_4Cl_4O_2As_2.1CH_3OH$: 13·95 cc. 0·1 *N* iodine; 11·16 mg. oxygen Found: Sol. mod., 10·80 mg. oxygen; insol. mod., 10·88.

In view of the fact that this compound cannot be recrystallised, the only method of purification consisting of redissolving in methyl alcohol-hydrochloric acid solution and reprecipitating from ether, we are reporting these results as the best we have been able to obtain thus far.

Calculated for $C_{12}H_{18}N_4Cl_4O_2As_2.1CH_3OH$: N, 9·76; As, 26·13. Found: sol. mod., N, 8·80; As, 26·62; insol. mod., N 8·80; As, 25·09 per cent.

Tetra-acetyl-3,3′,5,5′-tetra-amino-4,4′-dihydroxy-arsenobenzene.—Two g. of diacetyl-3,5-diamino-4-hydroxy-phenylarsinic acid is dissolved in 7·0 cc. of water by the addition of 4 cc. of 15 per cent sodium hydroxide solution. Two g. of magnesium chloride (crystals), and 10 g. of sodium hydrosulphite are dissolved in 45 cc. of water and immediately mixed with the solution of arsinic acid. The combined solutions are filtered rapidly, and warmed up to 55 or 60°. This temperature is maintained for 30 minutes, during which time the mixture is continually stirred. The precipitate which forms is yellow at first, but at the end of the reduction it appears white. It is filtered off, washed thoroughly with water and dried *in vacuo* over sulphuric acid. The yield is 1·2 g.

The compound is a white powder insoluble in water, dilute hydrochloric acid, and the usual organic solvents, soluble in glacial-acetic acid however. It is soluble in dilute alkalies, forming a yellow solution which is characteristic of arseno compounds; also soluble in dilute sodium hydrogen carbonate solution. Like all other arseno compounds it decolorises iodine, thereby becoming oxidised to its corresponding arsinic acid. This reaction cannot be utilised for its quantitative estimation, thereby differing from other arseno compounds, because of difficulty in distinguishing the exact end-point.

Calculated for $C_{20}H_{22}O_6N_4As_2$: N, 9·93; As, 26·60. Found: N, 10·14; As, 25·75.

Diacetyl-3,3′-diamino-4,4′-dihydroxy-arsenobenzene.—The method of preparation of this substance from acetyl-3-amino-4-hydroxy-phenylarsinic acid is the same as that of the tetra-acetyl compound described above. The yield is 73·17 per cent.

The substance is a pale yellow powder insoluble in water, methyl alcohol or sodium hydrogen carbonate solution, soluble in sodium hydroxide solution from which it is reprecipitated by hydrochloric acid.

Calculated for $C_{18}H_{18}N_2O_4As_2$, N, 6·22; As, 33·33. Founded: N, 6·16; As, 33·00.—*Journal of the American Chemical Society*, March, 1921.

MINERAL FERTILISERS IN JAPAN.

The production of pyrites was, in 1912, 82,600 metric tons, and 126,000 in 1913, since when it has increased. Moreover, we must consider the fact, that Japan is a great sulphur producer which favours manufacture of acid. Before the war, the production was, apparently, 30,000 metric tons, which has increased to 70,000. Subsequently to an agreement existing before the war, which was then cancelled and again restored, prices were fixed by a Convention in 1916. Sulphuric acid, *as in all other places, is utilised for manufacture* of mineral fertilisers, especially superphosphates. Imports of natural phosphates which, in 1913, amounted to 347,000 metric tons, fell to 322,000 in 1914, and even 189,000 in 1915; but the imports for 1916 and 1917 were estimated at 280,000.

However, Japan has developed her phosphate production in the Island of Rasa, Lu Choo, which from 740 metric tons in 1908 rose to 38,259 in 1914; 57,716 in 1915, and 114,810 in 1916.

Although the superphosphates obtained are largely consumed in the country itself, a considerable quantity is exported to Java, where 40 per cent *superphosphates are required*, and *also to* Russia. This market was only of interest during the war. *It seems possible to greatly develop the* utilisation of artificial fertilisers in Manchuria, where they are as yet little employed.

There are three principal manufacturing companies of fertilisers, viz., the Kuhard, the Furukawa, and the Sumitomo Co., the respective annual production being 7,000,000, 4,880,000, and 680,000 bags.

Consumption of sulphate of ammonia is about 140,000 metric tons. chiefly supplied by imports from England (110,000 metric tons in 1910). As during the war these imports almost ceased (20,000 in 1915) the Japanese have remarkably developed the industry.

The production of sulphate of ammonia was

40,000 metric tons in 1916, the amount for 1917 being estimated at 100,000, though really it was only 57,915, and in 1918 31,444. The German Aniline Consortium has decided, it is said, to found a works on the lines of those of Leuna, in Japan and the United States for fixation of nitrogen by the Haber process.

The employment of potash salts is insignificant; Chile nitrate imports were 24,694 metric tons in 1914.

The imports of mineral and other fertilisers in 1914 represented a value of nearly 80,000,000 francs. Home production is valued at about 225,000,000 francs, having tripled within the space of ten years.

In spite of this, Japan will probably always be dependent upon imports from abroad for part of the phosphates, potash salts, and nitrates, as long as manufacture of synthetic ammonia does not meet all requirements.—*L'Industrie Chimique*, May, 1921.

PROCEEDINGS OF SOCIETIES.

ROYAL SOCIETY.

Ordinary Meeting, June 23, 1921.

PROF. C. S. SHERRINGTON, President, in the Chair.

THE following papers were read :—

"*A Study of Catalytic Actions at Solid Surfaces. VI.—Surface Area and Specific Nature of a Catalyst: two Independent Factors Controlling the Resultant Activity.*" By E. F. ARMSTRONG, F.R.S., and T. P. HILDITCH.

The influence of the surface area of a nickel catalyst on its activity has been traced by examination of the bulk gravity of various types of catalyst: there exists a qualitative relation between bulk gravity and catalytic activity, the most efficient catalyst occupying the greatest volume per unit mass.

The rate of reduction in hydrogen of nickel oxide prepared in various ways has been examined at various temperatures. A light nickel oxide prepared from the precipitated hydroxide gave curves (hydrogen consumption/time) showing faint points of inflection at stages of the reduction which varied with the temperature of reduction; whilst dense, fused nickel oxide gave a smoother curve, and nickel hydroxide deposited on kieselguhr as a support showed a smooth, continuous curve.

The reduction curves are evidently related to the physical conditions (state of the oxide and temperature of reduction) rather than to the formation of any definite compounds intermediate in composition between nickelous oxide and nickel.

When a support (kieselguhr) is overloaded with nickel hydroxide and reduced so that varying proportions of the nickel are in the metallic state, the catalytic activity, measured by the hydrogenation of the unsaturated glycerides, increases rapidly to a maximum value, which is maintained thereafter until and when all the nickel hydroxide has been reduced to the elementary state.

The data given indicate that the activity is dominated by the condition of the surface layer of reduced nickel, since it is obviously this part of the mass which will be first reduced by hydrogen to the metallic state.

"*A Contribution to the Thermodynamical Theory of Explosions—Part I.; and Part II.—A Contribution to the Thermodynamical Theory of Explosions.*" Part I. by Sir J. B. HENDERSON, D.Sc. Part II. by Sir J. B. HENDERSON and Prof. H. R. HASSE.

In this paper modern advances in Chemical Thermodynamics, dealing with dissociation of gases and variation of their specific heats with temperature are applied to the science of internal ballistics, which has been in the past mainly empirical. Direct experiments on specific heats of gases are limited to temperatures below 1500° C., and extrapolation, based upon Thermodynamic Theory and extending to temperatures of 3500° C. and pressures of 20 tons/in.^{2}, tests the theory severely.

Part I. of the present paper, written in 1913-14 by one of the authors, contains the application of these theories to the calculation of the explosion-pressure of cordite in closed vessels, the results being in remarkable agreement with experiment. It also contains the calculation of the curve of adiabatic expansion of the products of explosion by considering a series of states of equilibrium and, following thereon, the ideal indicator diagram of a gun.

During the war confidential publication took place, and the curve of rise of pressure and the maximum pressure allowing for burning of cordite in parallel layers and for varying capacity of chamber during burning, due to movement of the projectile, were then calculated by the authors. The results have proved very useful in practice. They enable the indicator diagram of gun, maximum pressure, and muzzle velocity of projectile to be calculated with remarkable accuracy from the chemical composition of explosive used and rate of burning of the cords. They also show the effects, qualitative and quantitative, produced by variations in the different variables, initial pressure, density of loading, temperature of charge, diameter of cords, &c., and place internal ballistics on a better scientific foundation than formerly. Method and results are also applicable to internal-explosion engines using gas or oil.

"*Eddy Current Losses in Cylindrical Conductors, with Special Applications to the Alternating Current Resistances of Short Coils.*" By S. BUTTERWORTH.

The general theory of the eddy current losses produced in a non-magnetic metallic cylinder when placed in a transverse field of any form is developed, and a general series is obtained expressing the eddy-current losses.

From this series conclusions are drawn in regard to the modification of the losses by the want of uniformity of the field over the section of the cylinder.

The theory is applied to obtain an approximate solution of the problem of the effective resistance of two equal parallel wires carrying equal currents either in the same or in opposite directions. The formula obtained is shown to be in good agreement with Kennelly's experimental results.

The "uniform field" theory is applied to determine the effective resistance of parallel wire systems, and, by calculating the mean square field acting throughout the section of the coil,

formulæ are obtained for the effective resistances of single- and multi-layer solenoidal coils either of solid or of stranded wire.

The theoretical results in the case of single-layer solid wire coils at high frequencies are compared with measured values.

From the theoretical formulæ conditions are deduced in regard to the shape of coil and spacing, to employ which will produce the maximum value of L/R' for a given length of wire of given diameter.

Solid wire coils are compared with stranded wire coils, both being wound under the most efficient conditions.

The observed inferiority of stranded wire coils as compared with solid wire coils at high frequencies is due to the lack of internal spacing of the strands of the coils making the the best conditions unattainable.

The theoretical conditions for the minimum effective resistance of a many-layered coil of given inductance and resonating with a condenser of given capacity are worked out.

"The Currents induced in a Cable by the Passage of a Mass of Magnetic Material over it." By E. S. BIELER.

The electromotive force induced in a cable by the passage of a mass of magnetic material over it is investigated in the case where the mass is in the form of a spherical shell. The deflection of a critically damped galvanometer in series with it is deduced.

The results of the theoretical investigation are compared with those of experiments carried out in the laboratory on a small scale, and good agreement is obtained in each case.

In conclusion, the theoretical results are used to determine the law of variation of the galvanometer with different factors, and the relation between the galvanometer deflection and the E.M.F. which produces it.

"The Experimental Analysis of Sound in Air and Water: some Experiments towards a Sound Spectrum." By GUY BARLOW, D.Sc., and H. B. KEENE, D.Sc.

The original sound vibration gives rise to an electric current of telephonic magnitude, which is then analysed by a method of periodic interruption, whereby the frequencies and relative amplitudes of the constituents may be determined, and a "sound spectrum" constructed. A specially controlled motor-driven interrupter, with a range of interruption frequency from 3—2000/sec. is placed in series with a Broca galvanometer in the circuit containing the alternating current to be analysed. The speed of the interrupter is then slowly varied over the whole range of frequency under investigation. When the interruptions synchronise with any component of the current, the galvanometer responds by giving a steady deflection whose magnitude depends on the phase difference, and this latter can be adjusted to give the maximum response. In this way the amplitude of each component may be determined, and at the same instant the corresponding frequency is observed stroboscopically.

Experiments are made (1) to test the reliability of the method by analysing alternating currents containing known constituents; (2) to analyse different types of sound in air, using both carbon microphone and magnetophone receivers; (3) to analyse sounds in water (in a reservoir), for which special sounders and receivers are constructed and describe. The variations of the sound spectrum with distance, depth, and direction are investigated, and the spectrum of a motor-driven boat is obtained under various conditions.

"The Theory of the Analysis of an Electric Current by Periodic Interruption." By GUY BARLOW, D.Sc.

This paper contains a mathematical treatment of the methods of periodic interruption used in the experimental analysis of sounds described in the previous paper, together with an expansion of the effects of periodic interruption on the intensity and quality of sounds heard in a telephone.

SOCIETY OF GLASS TECHNOLOGY.

THE last meeting of the Society of Glass Technology for the session 1920-21 was held in the Applied Science Department, The University, Sheffield, on Wednesday, June 15, 1921, at 2.30 p.m., the President, Dr. MORRIS W. TRAVERS, F.R.S., in the Chair. The initial formal business included the election, under rules recently adopted, of Prof. P. G. H. Boswell, O.B.E., D.Sc., D.I.C., F.G.S., Professor of Geology in the University of Liverpool, as the first Honorary Member of the Society.

The meeting resolved itself into a discussion on the subject of "Oil Firing in the Glass Industry." The President, in opening the subject, said that he would restrict his own remarks to the consideration of the efficient utilisation of energy in two types of furnaces. If one purchased oil or coal, one actually purchased energy which might, or might not, be represented by the calorific value of the fuel. What one really had to consider was the energy available for melting glass or for other similar purposes.

He showed, by means of thermo-chemical calculation that the relative fuel efficiency of a furnace in which the oil was burned with air at the ordinary temperature, and of a furnace in which coal was first gasified by air with only a little steam, the gas being burned with air at the ordinary temperature were practically identical. That non-regenerative glass tanks fired with oil were preferred to those fired by gas was due to the fact that small gas-fired tanks were probably inefficient. He left the consideration of such questions as capital cost, working expenses, and control to other speakers.

In oil-firing practically the whole of the air could be pre-heated, but in gas-firing only the secondary air could be pre-heated, so that a regenerative oil-fired furnace was more efficient than a furnace in which the secondary air was pre-heated. Other conditions being equal, the ratio of the efficiency of the oil and gasified coal systems was as 1·37 to 1. The results might be summed up as follows :—

	Net calorific value.	Cost in London per ton.	Efficiency of combustion.	Relative cost.
Oil	10500	105/-	1·37	1·20
Coal	7420	45/-	1·00	1·00

This did not take into account the other factors to which he had referred which favoured the use of oil.

Mr. J. CONNOLLY remarked that one of the chief points to be considered was the price of the

oil. It had undoubted advantages in respect of ease of handling, reduced storage room required, less staff, and less expensive furnace construction. He had run an oil glass furnace for four years. It worked with fewer breakdowns and stoppages, and more pleasantly than any other method. At the end of that period, however, the price of oil was "gingered up," and the use of the oil was abandoned. The adaptability of oil to glass work had been demonstrated, and was past argument, but he did not think they would get a higher efficiency with oil than with coal, so long as there was a great difference in price. There was a more steady dependence on the price of coal than of oil.

Mr. J. H. STEELE thought that oil had not been given a fair chance in the glass industry. His own experience of it was very satisfactory. It was unusual, however, to find a glass furnace properly adapted to oil consumption. He had known better results to be obtained from the use of crude oil or creosote than from fine petroleum of high calorific value; a fact which indicated that the furnaces in use were not satisfactory.

Mr. F. G. CLARK spoke of the use of "glory holes" fired by oil. The best results were obtained from crude creosote oil, partially heated, and compressed air at about 15lb. to 20lb. pressure per square inch. In making 8oz. bottles on a 7½-hour shift, some 3·92 gallons of oil were used, at a cost of 4s. 3d. per shift. When two chairs were working at one glory hole, the cost worked out at about 2s. 2d. per shift. Gas did not yield the temperature desired, and creosote oil gave a fuller and "fatter" flame than did petroleum. Consequently the neck of the bottle was heated up more uniformly, and much better finished work was produced.

Mr. G. F. LAWTON described a simple oil burner that had yielded good results. In one power station 1 ton of oil was apparently equivalent to about 2½ tons of coal. They must consider very carefully the construction of the furnace and the proper application of the oil.

Mr. J. VENN STEVENS pointed out the advantages of oil fuel for glass furnaces. It was clean to use. Besides, the flame came into direct contact with the glass without producing any discolouration or deterioration. The temperature could be maintained uniform, thus saving many articles which would be ruined by the fluctuations of temperature due to unsteady firing.

Mr. A. BAYLISS remarked that the *Aquitania* had in the stokehole 350 men when fired with coal, but only 84 with oil fuel. With solid fuel the efficiency might range from 50 per cent to 65 per cent. In the case of oil fuel the efficiency might be as high as 85 per cent. In addition, there was instantaneous ignition and extinction. The freedom from sulphur in the gases formed by combustion was an important point for glass workers.

Mr. W. H. CASMEY referred to the very great potentialities of oil when mixed with inferior qualities of solid fuel. In one case by taking 3 tons of coke breeze (at 12s. 6d. per ton, calorific value 10,000 B.Th.U.) and one ton of oil fuel, a combined fuel of 12,000 B.Th.U. was secured, equalling 37s. 4d. per ton, and capable of giving an evaporation of 530lb. per 1s., or nearly 2,000lb. more evaporation per ton than with coal only at 40s. per ton.

Mr. W. J. REES thought it was very necessary for some reliable figures to be obtained showing how efficient coal-firing was compared with oil-firing.

Prof. W. E. S. TURNER read a communication from Messrs. Stein & Atkinson, Ltd., and a diagram was exhibited and explained showing the proposed design of a combustion chamber for the oil-firing of a glass tank furnace. Prof. Turner also read a communication from Messrs. Shell-Mex, Ltd., in the course of which it was stated that there were very few oil-fired pot furnaces in this country. The few that had been tried had not been entirely successful, the chief trouble being the cracking of pots. This was due to excess of heat in one particular place on the pot, causing unequal expansion. A method of avoiding this was suggested.

The discussion was continued by other speakers. Burners or drawings of plants were also exhibited by the following firms: Messrs. Alldays & Onions, Ltd., Birmingham, Anglo-American Oil Co., Ltd., London, Holdsworth & Sons, Ltd., Bradford, Kermode's Ltd., Liverpool, Lawton Machine Tool Co., Sheffield, White Patent Oil-burning Co., Ltd., South Shields, J. Samuel White & Co., Ltd., Cowes, Isle of Wight.

PHYSICAL SOCIETY.

June 10, 1921.

DR. C. H. CHREE, F.R.S., Vice-President, in the Chair.

A LECTURE on "*The Stability of Atoms*" was delivered by Prof. SIR ERNEST RUTHERFORD, F.R.S.

The lecturer commenced by referring to the earlier work in which attempts at the disintegration of atoms had been made. Traces of hydrogen and helium had been found in discharge tubes believed to be initially free from these gases; but it was clearly impossible to establish that no source of contamination was available, and that the results were due to disintegration of the atoms of other substances.

The properties of the nucleus atom were then recalled and the method of attack most likely to succeed in breaking it up was discussed. It is easy to remove electrons, but these are replaced almost immediately and the atom remains as before.

It is necessary therefore to attack th enucleus, and to do this successfully requires extremely swift particles.

Slides were shown illustrating the effects produced when α-particles fired through hydrogen collide with an atom, and experiments were illustrated and described from which the conclusion had been drawn that when an α-particle collides with a nitrogen atom, a hydrogen atom is expelled from the nucleus. The speed of these is in excess of what can be obtained by collisions in hydrogen gas itself, so that the result cannot be accounted for by contamination of the nitrogen with hydrogen, but must be due to the disintegration of the nitrogen nucleus.

Recent results on the disintegration of aluminium and other elements were briefly indicated.

The CHAIRMAN expressed the thanks of the Society to SIR ERNEST RUTHERFORD for his

address. Queries were put by Dr. Andrade, Dr. Owen, and Dr. Rayner, to which the Lecturer replied.

MINERALOGICAL SOCIETY.

June 21, 1921.

Dr. A. E. H. Tutton, Past-President, in the Chair.

"*A Note on Crystal Measurement.*" By Dr. H. Hilton.

It was pointed out that considerable labour could be saved by measuring the angles between zones through two faces instead of the angles between zones through one face and the angels between this face and the rest. A point of geometrical interest in connection therewith was also discussed.

"*The Trend of Reconstitution Processes in Shales, Slates, and Phyllites.*" By A. Brammall.

The author correlates microscopical data with data deduced from chemical analyses. The finely powdered rock is extracted with (a) 20 per cent hydrochloric acid; (b) 50 per cent hydrochloric acid, and these extracts are analysed and discussed with reference to the molecular proportions of the bases present. The residual slime is treated with dilute hydrofluoric acid, freed from silica gel, and thoroughly washed. Free carbon particles are floated off by the froth produced on vigorously shaking up the slime in a flask half full of water, to which a few drops of amyl alcohol, paraffin, and sodiu msilicate have been added. Samples of coarse-grade and fine-grade sericite are separated by elutriation and analysed. Heavy or insoluble residues are obtained and examined. In this paper, data referring to Bolivian rocks (collected by Dr. J. W. Evans), and, for comparative purposes, to the Skiddaw Slate, are discussed. Work on the rocks of North Devon and North Wales is in progress. Trend, in general, is towards the establishment of a metastable ternary system of white mica, chlorite, and quartz, by a process of molecular differentiation: (a) Monad-oxides, type R_2O allied with, alumina, silica, and water (mica); (b) diad-oxides, type RO, allied with alumina, ferric oxide, silica and water (chloritic matter); and (c) free silica (quartz). In the early stages this differentiation is imperfect; the mica contains iron oxides, magnesia, &c., and the chloritic matter adsorbs alkalies. The identity of mineral species evolving from the chloritic matter depends partly upon the molecular ratio R_2O_3 : RO, and this in turn depends partly upon the reduction of ferric oxide to ferrous oxide. The development of rutile, ilmenite, epidote, &c., is probably subordinate to the main trend.

"*The Micropetrography of the Rock-Gypsum of Nottinghamshire.*" By W. A. Richardson.

Microscopic examination reveals a wide range of structural types, including many metamorphic types. The evidence supports the view of B. Smith that the main series is of sedimentary origin, and that the nodular deposits are segregations. The metamorphic effects appear to be due to pressure caused by the partial or complete hydration of the anhydrite.

OBITUARY.

Mr. A. P. SINNETT.

We regret to announce the death of Mr. A. P. Sinnett, Vice-President of the Theosophical Society, which took place at his residence in Ladbroke Grove, on June 25. Mr. Sinnett was an old friend of Sir William Crookes, and a well-known writer on theosophical matters. For many years he has been a familiar figure at the meetings of the Royal Institution. He was of a quiet, kindly disposition, and was respected and esteemed even by those who failed to agree with many of his conclusions.

CHEMICAL NOTICES FROM FOREIGN SOURCES.

Comptes Rendus Hebdomadaires des Séances de l'Academie des Sciences. Vol. clxxii., No. 25.

"Absorption of Oxides of nitrogen by Nitric and Sulphuric Acids."—By A. Sanfourche.

"New Magnesium Hydraulic Cement."—By A-Ch. Vournazos.

"Catalytic Decomposition of some Polyhalogen Aliphatic Hydrocarbons."—By Alphonse Mailhe.

"Catalytic Decomposition of Bromacetic Acids, and of some mixtures of Bromine and Acetic Acid."—By J. B. Senderens and J. Aboulenc.

"Distribution of the Saline Substances and the Mineral Elements in Milk."—By Ch. Porcher and A. Chevallier.

NOTES.

Royal Institution.—A General Meeting of the Members of the Royal Institution was held on the 4th inst., Sir James Reid, Vice-President in the Chair. Miss F. E. I. Smythe and Mrs. A. J. Webbe were elected Members. The Chairman announced that the Managers had re-elected Sir James Dewar Fullerian Professor of Chemistry.

The Library of the Chemical Society will be closed for Stocktaking from August 1 to 13 inclusive, and will close each evening at 5 o'clock from August 15 to September 10.

The recently-formed Glass Research Association has issued its first bulletin in the form of a confidential communication to its members. The publication consists of a booklet of some 43 pages, well illustrated with photographic reproductions, and constitutes a fine record of work. Papers upon the cause of Cords in Glass, the nature and cause of Bloom and Dimming on Lamp-blown Glassware, new Microfurnace for Glass Examination at High Temperature, and the purification of Mercury for use in Thermometers, are recorded. Notes on Abrasives, the effect of Chlorides on the Melting and Working of Lead Potash Glass, Refractories, &c. Experimental work in glass-making upon a large scale will be carried out at the Sheffield University under the supervision of the Director or Research, Mr. R. L. Frink, in collaboration with the members of the various re-

search committees that have been formed to deal with special questions. The Association appears to be dealing with the important problems of the British Glass Industry in a practical way, and the result of its labours will have great influence upon tbe future of British glass manufacture.

An Exhibition, to take place at the Crystal Palace between September 1 and October 22 is being organised, with the title of the "Co-Partnership Exhibition," and one of its objects is to record the remarkable movement that has been made in recent years to promote industrial peace between employers and employed.

We learn from the *Scientific American* that Dr. Charles Benson Davis, of New York City, claims that he can make the Elements, gold, silver, copper, and platinum by transmutation of the common element. Dr. Davis is said to be a Fellow of the more important English and French Scientific Societies, and has requested the Engineering Foundation in New York City to investigate his claims. We shall naturally be interested to hear the result.

We have received from the Managing Director of the British Road Traffic Association a copy of the new Motor Time Table, the Motor A.B.C., which gives full particulars of the daily motor service, compiled in such a way that it is perfectly simple for anyone wishing to travel by motor-coach to find in a few minutes exactly what services are available on the route he wishes to use, the starting point, starting time, fares, and booking office for each coach, and he is able to make his arrangements with the least possible delay or worry. This method of travelling is becoming increasingly popular, and great changes will undoubtedly take place in the near future In addition to motor services, the A.B.C. gives the Aeroplane facilities, together with fares, &c. The Motor-Coach A.B.C. is published by Messrs. E. J. Larby, Ltd., 30, Paternoster Row, E.C., price 6d.

The Telephone Service. — Messrs. Geo. Wheatley & Co., Ltd., have published and will supply free on application to their London Offices, 95, Upper Thames Street, a useful little booklet showing at a glance the new method of "charging by distance" between subscribers connected with the Exchanges within the inner London Zone, as well as the cost of a call to points outside the 1½ limit within a radius of 25 miles of London, and other data of value.

Refractory Material.—Roast recommends a mixture of Greenwille magnesite burnt at 1700° C. and magnesium chloride as an excellent refractory material. One application of magnesite is for manufacturers of Sorel cement a mixture of magnesia and chloride of magnesia forming a vitreous block of oxychloride. Substances like sawdust or sand can be incorporated to make very sound, strong floors without grooves. It is also employed for manufacture of magnesia bisulphite to prepare wood pulp for paper, precipitated carbonate of magnesia for pharmaceutic products, insulating steam pipes, and finally, as a base in electrolytic preparation of magnesium for alloys, especially with aluminium.—*Industrie Chimique*, March, 1921.

Formation of Hevea Latex in the Hevea Brasiliensis.—The globules of latex, according to W. Bobiloff (*Archief Rubber Cultuur*, 1919, 3374), derived from the mature parts (trunk, &c.) of the Hevea, usually comprise four kinds, viz., (a) round, very small globules, diameter 0·5μ; (b) round, larger globules, diameter 1—2μ; (c) pear-shaped globules with tail, diameter 1·5—2μ; (d) pear-shaped globules, diameter 1·5—3μ. There are only very small round globules in the branches, leaves, and young roots. M. Bobiloff concludes that the latex in new branches is quite independent of that in the remainder of the tree, and that the latex forms in the laticiferous tissue itself.—*Le Caoutchouc*, February 15, 1921.

Chemical Action of Light.—At the request of Ciamician and Silber, Sig. E. Sarnagiotto made researches on the chemical action of light. The results are summarised as follows. The property of autoxidation of oxalic acid in light is associated with oxidation of ethyl alcohol and glycerin. Thiophene undergoes autoxidation in light. Dibenzyl and benzophenone are condensed in benzophenone-pinacone and triphenylbenzylethanol. Quinone and toluene reacted under the action of light in a confused way. However this may be, the quinone was transformed into a brown resinous mass accompanied by some crystals of hydroquinone and quinhydrone. Toluene left traces of benzoic aldehyde. The acetone and amyl alcohol gave a resin and various compounds: (1) Dimethylisobutylenic glycol; (2) Isopropylbutylcetone; (3) Diisobutylethylenic glycol. —*Gazz. Chim. Ital.*

NEW COMPANIES.

The under-mentioned particulars of New Companies recently registered are taken from the Daily Register compiled by Jordan & Sons, Limited, Company Registration Agents, Chancery Lane, W.C.2.

Faulkner's Drug Stores, Limited.—(175308)—Registered 21st June, 1921. 1, Church Street, Cobham, Surrey. To acquire and carry on the business of Drug Stores. Nominal Capital: £500 in 500 Ordinary Shares of £1 each. Directors: H. B. Faulkner, 1, Church Street, Cobham, Surrey: (Managing Director); H. Ivimey, 4, Priory Road, Hastings; L. Whitehouse, 319, Stratford Road, Sparkbrook, Birmingham. Qualification of Directors: 1 Share. Remuneration of Directors: To be voted by Company.

Morgan Brothers (Chemists), Limited.—(175381)—Registered 24th June, 1921. 1, Strand Buildings, Ystradmynack, Glamorganshire. To acquire and carry on the business of Chemist and Drug Store Proprietor. Nominal Capital: £2,000 in 2,000 Ordinary Shares of £1 each. Directors: To be appointed by Subscribers. Qualification of Directors: 1 Share. Remuneration of Directors: To be voted by Company.

James Johnstone & Company, Limited.—(175353)—Registered 23rd June, 1921. Abbey Hey Lane, Gorton, Manchester. To carry on the business of Chemists, Druggists, Oil and Colourmen, etc. Nominal Capital: £2,000 in 2,000 Shares of £1 each. Directors: James Johnstone, 132, Hyde Road, Gorton, Manchester: (Paint Manufacturer); John Johnstone, 132, Hyde Road, Gorton, Manchester: (Paint Manufacturer). Qualification of Directors: £50. Remuneration of Directors: To be voted by Company.

H. J. Parsons, Limited.—(175335)—Registered 22nd June, 1921. Market Place, East Street, Ilminster. To acquire and carry on the business of General Chemists and Druggists. Nominal Capital: £2,000 in 1,500 Ordinary Shares and 500 6% Preferred Shares of £1 each. Directors: H. J. Parsons, East Street, Ilminster; I. J. Morgan, The Butts, Ilminster. Qualification of Directors: 1, Share. Remuneration of Directors: To be voted by Company.

Shepperleys, Manufacturing Chemists, Limited.—(175290)—Registered 20th June, 1921. To acquire and carry on the business of Wholesale and Retail Chemist and Druggist. Nominal Capital: £30,000 in 20,000 Preferred Shares and 10,000 Ordinary Shares of £1 each. Minimum Subscription: 7 Shares. Directors: J. R. Hex

43, Chancery Lane, W.C.2; P. B. Symonds, The Mount, Symonds Yat, Ross-on-Wye; J. E. Shaw, Middle Pavement, Nottingham; C. Middleweek, Emerson Lodge, Sherwood, Nottingham. Qualification of Directors: £5500. Remuneration of Directors: To be voted by Company.

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New Patents.

This List is specially compiled for the *Chemical News* by Messrs. Rayner & Co, Registered Patent Agents, of 5, Chancery Lane, London, W.C.2., from whom all information relating to Patents, Trade Marks and Designs can be obtained gratuitously.

Latest Patent Applications.

16320—Chambers, E. V.—Treating waste, etc., liquors containing ferrous chloride. June 14.

16526—Maeder, H.—Process for preparation of tropinone-mono-carboxylic acid esters. June 15.

16743—Mau, W.—Manufacture of concentrated hydrogen peroxide solution. June 17.

16248—Toniolo, C.—Drying or eliminating water vapours from nitric or nitrous acid vapours from gases derived from oxidized ammonia. June 13.

16265—Volart y Jubany, R.—Manufacture of hydrochloric acid. June 13.

16368—Durand & Huguenin Akt-Ges.—Manufacture of halogen derivatives of basic acridine dye-stuffs. June 18.

Specifications published this Week.

14374—Dreyfus, H.—Manufacture of cellulose derivatives.

14384—Dreyfus, H.—Manufacture of products having a basis of cellulose derivatives.

17529—Bielouss, E.—Process for the production of amino-compounds from trinitrotoluol.

14627—Unione Italiana fra Consumatorie Fabricani Di Concumie Prodotti Chemical & Sonneck, A.—Manufacture of sulphuric acid.

Abstract Published this Week.

Catalytic Hydrogenation of Fats, etc.—Mr. E. R. Bolton of ilner Street, London has obtained a Patent No. 162370 for an iproved treatment of fats, etc., in which the catalyst for use in the drogenation of fats or oils consists of nickel wool which has en activated by the action of an acid such as nitric acid upon its rface, followed by conversion of the layer of nickel salt to oxide .d reduction in hydrogen. The reaction chamber is packed with e activated nickel wool and the oil and hydrogen passed through counter-current. After use the catalyst is regenerated by first moving nickel soaps by washing with the hot oil, then removing .e oil by solvents and finally heating in hydrogen. According to e provisional Specification, the nickel wool may be activated by ternate oxidation and reduction, the catalyst may be electrically eated, and a number of reaction vessels may be arranged in series.

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PAPER-PULP SUPPLIES FROM INDIA.*

By WILLIAM RAITT, F.C.S.
Cellulose Expert to the Government of India, attached to the Forest Research Institute, Debra Dun, India.

It is a commonplace observation now that the question of the world's paper supply has arrived at an acute stage. We see it referred to in more or less lachrymose tones in almost every newspaper we take up. Our pockets test it daily in handing out twopences instead of pennies; the fivepenny five-quire packet, with twopence for twenty-five envelopes, and the halfpenny newspaper have disappeared; and we are studying economy in a direction we never thought of before.

In 1913, the world's consumption of paper was estimated at ten million tons annually, increasing at the rate of 25 per cent every ten years. It must be now nearly twelve millions, or would be if the supplies were available. Of this about 80 per cent is produced from wood—coniferous wood, and preferably spruce. In 1913, although there had been a slow but gradual appreciation of values during the previous ten years, it was still possible to deliver chemically-prepared pulp in this country at £9 to £10, and mechanically-prepared, or ground wood-pulp, at £5 10s. to £6 per dry ton, and newsprint paper could be produced for a penny per pound. Now values are four to five times these figures. The causes stated in order of their importance from lesser to greater are these:—

(*a*) The slow but gradual rise of values in pulp and all that it depends upon, dating from the period of lowest prices, about fifteen years ago. During the war this was, by reason of controls, restrictions, and reduced consumption more or less in suspense, but has now fallen on the industry with five years' cumulative effect.

(*b*) The universal appreciation in value of timber for constructional purposes. The sawmill is now a better market than the pulp factory.

(*c*) Effects of the war in permanently increased costs for labour, freights, fuel, and machinery, and equipment.

(*d*) The total cessation of six years past of manufacturing expansion.

(*e*) The demand for wood has outrun the supply. The trees will not grow as fast as they are cut.

The last of these is the root cause of the trouble and is a constantly increasing menace. It does not necessarily imply that he world's stock of timber has been seriously depleted, but it does mean that forests most favourably situated for exploitation—the areas which produced the penny per pound newsprint—have been largely reduced in productiveness and in many instances destroyed for ever. Expansion in wood-pulp production must seek its supplies at greater distance and increased cost. Notwithstanding this, the new values of pulp, making all allowances for temporary inflation, render such expansion abundantly justified. How much greater, therefore, is the justification for the introduction of a material which is one of Nature's waste products, which reproduces itself naturally and rapidly, for which no sawmill competes, and which offers itself at Nature's valuation, which is next door to nothing.

So we ask ourselves the question, what can India do to fill the gap which has been created? The answer is a great deal, though not so much, perhaps, as is sometimes assumed. When the threatened shortage of paper supplies began to be agitated, some fifteen years ago, an eminent scientist issued what was intended to be a re-assuring statement to the effect that "a paper famine was unthinkable, because paper could be made from any vegetable substance, and the world teemed with that." The dictum was seized upon by the Press and circulated round the world, and, no doubt, brought comfort to many anxious consumers. But like many other assertions of many other eminent scientists, it was considered as cold fact, perfectly true, and at the same time, considered as a practical contribution to a difficult problem, perfectly misleading and fallacious. Paper can be made from any vegetable substance, but money cannot, and the paper-maker has a quite natural reluctance to make paper unless he can transform it into bank notes. But our eminent scientist's utterance gave rise to a whole crop of wild-cat proposals to make paper from everything, anything, and sometimes bordering on nothing. Nature, however, is not so fantastically generous as that. He whom she would favour must delve into her secrets slowly, deeply, carefully; hoping all things, proving all things, until finally he can hold fast to that which is good. This has been in essence the principle upon which the investigations of the Indian Forest Research Institute, to which I am about briefly to allude, have been carried on. We have thought it more important in the early stages of our proceedings to save people's money than to teach them how to make it, for nothing is more fatal to a promising industry than a disastrous failure at its start. At the same time, while paying considerable attention to the how-not-to-do-it programme, and weeding out the "duds," we have met with encouraging success on the positive side. Our eminent scientist was an all-in, whole hog, hundred per cent man. We have knocked ninety-five off that, but remain quite pleased with the five which have survived. The truth is that out of the hundreds of thousands of species available, a large number have to be rejected because of the cost of isolating their cellulose, a further large number because the cellulose is no good when you have got it, not to mention others which grow in economically inaccessible situations or are too valuable for other purposes. The net result is that so far we have found only two small groups, both belonging to the Gramineæ, which are economically sound as regards the quantity and quality of their cellulose, and the manufactring conditions under which they can be exploited. These are bamboos and a few Savannah grasses. But, though few in number, in the aggregate they mean something considerable. It is, I think, a modest estimate to say that from bamboo, taking only that which is available under *possible* manufacturing conditions, Burma, Bengal, and South-West India could produce ten million tons of pulp per annum, and Assam, from Savannah grasses, three million. India could, therefore, produce pulp for the whole world.

*From *Journal of The Royal Society of Arts*, June 24, 1921. (By permission).

Consider also the growth conditions under which this is obtainable. To grow a spruce or fir tree of pulpwood size takes from 40 to 60 years, with the result that a factory which may at its start have its supplies at its back door finds these year by year receding into the distance with constantly increasing transport costs. Bamboos and grasses come to maturity as yearly or eighteen monthly growths, and all you have to be careful of is not to reduce the reproductive vigour of the plant by too frequent cropping. With bamboo this may mean a three to five year rotation of cropping, and with grasses two to three years. We must, therefore, have a sufficient area to exploit to allow of these rest periods, but that only means that for a ten-thousand-ton pulp output per annum, with average figures for yield and rotation, a 20,000-acre reserve will keep a factory going in perpetuance—a vastly different condition of affairs from those governing a wood-pulp installation which lives on its capital from the start or must adopt a reafforesting policy, which reacts badly upon costs.

Bamboo for paper-making is no new suggestion. In the seventies the late Thomas Routledge, well known as the successful pioneer of esparto grass, experimented with it, obtaining encouraging results as far as quality and suitability were concerned, but failing on the economic side, partly because of its resistance to bleaching, but chiefly because just at that moment wood-pulp came in with a rush and more than filled the demand. In 1905 Mr. Sindall, at the instance of the Government of India, carried out an extensive investigation in Burma, with results considerably more encouraging than those of Routledge, though still somewhat disappointing on the bleaching side, and, at that date, cheap wood-pulp still controlled the market. In 1909 the Government of India, at the instance of Sir John Miller and Sir Robert Carlyle, who succeeded him as Member of Council for Revenue and Agriculture, deemed the time had arrived for a thorough enquiry into the whole subject, and handed it over to the officers of the Forest Research Institute, then under the Presidency of Mr. R. S. Pearson, conducting the Forestry side of it. The chemical branch was begun at the Allahabad Exhibition of 1910, under the Presidency of Sir John Hewett, then Lieut.-Governor of the United Provinces, and the directorship of Mr. P. H. Clutterbuck, Conservator of Forests, and afterwards continued at the Forest Research Institute. Hitherto the Institute's laboratory work has been supplemented by tests at paper mills, by the courtesy of their owners, but Government has now ordered in Scotland a complete pulp and paper-making plant on a sufficient scale to permit of factory methods being used. This is to be erected at the Institute, and will immensely reinforce its usefulness. I would like in passing to call attention to Government's policy in thus carrying out the enquiries initiated by Sir John Miller, Sir Robert Carlyle, and Sir John Hewett, as an evidence of its keen interest in the industrial development of the country.

The chemical branch of the enquiry was begun under conditions considerably more favourable than those with which Routledge and Sindall had to work. The uncertainties on the forestry side had been largely cleared up by Mr. Pearson's work, so there was no longer the risk of wasting time and effort on species and areas which he had shown to be of doubtful value. Considerable improvements had been arrived at in digestion methods, and particularly in the recovery and re-use of soda from the waste liquors, largely reducing the cost of chemical treatment. In Routledge's time a recovery of 40 per cent was regarded as good; now from 80 to 90 per cent is not unusual. Most important of all, market values of wood-pulp were no longer on the down grade, and the call for a new source of supply was becoming insistent. The problems to be faced were mainly those concerned with the cost of bleaching. It was evident that the dark brown colour of the unbleached pulp hitherto produced was not its natural and unadulterated colour, which in carefully prepared samples is a light grey, faintly tinted with brown. The dark brown was a degradation result produced by the re-absorption by the *Cellulose*—which, as evidenced by its use in blotting paper, is one of the most absorbent substances known—of some of the complexes produced by the combination of soda with the solubles in the raw material. The first step in the enquiry, therefore, resolved itself into the isolation and separate examination of these. This resulted in the separation of the plant constituents into a series of groups, based on their degrees of solubility. Each of these groups is a complex one, exhibiting the group substance in several forms and types, all of which are of interest to the organic chemist, and upon which much valuable work has been done by Cross and Bevan and others—in fact, it is upon the foundations laid by Cross and Bevan that our work has been built—but what interests the pulp manufacturer chiefly is the problem of getting into solution the non-cellulose constituents of his raw material.

Proceeding on these lines, it was found possible to separate the plant constituents into four groups having marked and striking differences of solubility. In order of solubility beginning with the least resistant they are:—

GROUP I.—*Starch* and its secondary and transformation products—all soluble in boiling water.

GROUP II.—*Pectose* soluble in one to two per cent caustic soda solution at boiling temperature.

GROUP III.—*Lignin* soluble in four per cent caustic soda solution at temperatures over 130° C.

GROUP IV.—*Cellulose*, the insoluble residue.

An average analysis of bamboo on these lines will give results in round figures as follows:—

	Per cent.
Starch group	12
Pectose ,,	20
Lignin ,,	15
Cellulose ,,	53
	100

There is also a trifling amount of wax and silica in the cuticle which goes into solution with the Pectose group.

The characteristics of the three soluble groups in their behaviour with soda are as follows:—

Starch in its primary form gives a clear colourless solution, but its quantity present in a total group content of 12 per cent does not exceed a sixth. The other 10 per cent of secondary starches form a dark brown nearly black solution of great pulp staining power. The *pectoses* yield a dark brown staining solution which is gelatinous, and therefore powerfully resistant to removal by washing prior to bleaching the pulp. The *lignins* give

a pale brown or amber coloured solution, clear, limpid, and not gelatinous, so that its faint stain is removable by washing. Now, since the raw material does not break down into pulp, and *therefore into a condition permitting re-absorption*, until the lignin has been removed, the next step seemed clearly indicated, viz., remove the substances which produce the objectionable stain on the pulp *before you attack the lignin*. It is fortunate that Nature has made her arrangements to facilitate such a separation process. She gives a beautifully graduated ascending scale of solubilities combined with a descending scale of staining effects. Had the opposite condition prevailed, had the most resistant, lignin, been also the worst staining factor, we should have come up against a dead end.

Cellulose and lignin in combination form that old acquaintance of our school days, woody fibre, yet the analysis is very dissimilar from that of the substance we usually describe as wood, which has a much larger proportion of lignin. The pectose group is replaced by a comparatively small content of resins and gums, while the starch group is barely recognisable in a small percentage of mucilage. The large quantities of starch and pectose found in bamboo and in all Gramineæ, are not in combination with the lignified fibre, but represent stages of transformation in the plant's laboratory of the primary food substance, starch, into the ultimate permanent products, lignin and cellulose. In speaking of lignin as a group, some qualification is necessary. It certainly exists in several types of varying resistance, hut not necessarily in the same plant. It is the substance which gives rigidity and resistance to the cellulose against the opposing forces of wind, rain, and decay, and it does not appear likely that Nature wastes effort in providing annual grasses with a protecting medium of the same resistance as that necessary for a tree which may live for centuries, and this hypothesis is borne out by facts. Thus, esparto grass, which exists for a few months, has only about 6 per cent of a lignin which is capable of reduction at temperatures below 130° C., and may even be dealt with by strong soda solutions and prolonged treatment at ordinary boiling temperature, whereas wood may contain as much as 40 per cent of a lignin which is strongly resistant to great density of soda at temperatures as high as 170° C. Bamboo, the life of which is not more than 30 years in the case of the longest-lived species, is provided with a lignin intermediate to these in quality, capable of attack at 130° C., although not fully soluble under 150° C.; the difference between these figures being probably due to physical causes related to penetration of the reagent into a dense, compact, and colloidally protected structure.

From these results we evolved the process which has been called Fractional Digestion, to distinguish it from the earlier method of overhead digestion—"overhead" in the sense that all solubles are dealt with together by a treatment drastic enough to secure the resolution of their most resistant member, and therefore, unnecessarily severe for the less resistant groups, which leaves the pulp steeped in a residual liquor, containing all the objectionable staining matter referred to. Such a system has for long been recognised as scientifically unsound, and we think we have proved it to be also economically unsound. It must necessarily be conducted with a large and wasteful excess of soda, first, because the lignin is not attacked until the digestion temperature has risen above 130° C., at which stage the starch and pectose groups have already been brought into solution, and have neutralised a considerable amount of the soda. That which remains will not be of sufficient strength to deal effectively with the lignin unless the original liquor contained a large excess. In this connection it is well to bear in mind the effect which density has upon the activity of soda solutions. You may have present the total quantity of soda necessary to effect your object, but if it is distributed throughout so large a volume of water that density is reduced below a certain well-marked degree you will not get the result you wish. A notable example of this is provided in the mercerisation of cotton cloth. The minimum density we have found necessary to give rapid and effective resolution of the lignin of bamboo is that represented by a 4 per cent solution of standard caustic soda, and it must be of this density at the point at which the attack on lignin is commenced. Under the limitations of the overhead method, it will not be of this density at that point unless it carried, at the beginning of digestion, a very large excess. Now, since the theoretical quantity of soda required to neutralise the acid bodies, pectose and lignin, is only about 16 to 17 per cent, it is evident that the overhead method, with its consumption of 25 to 27 per cent is compelled to employ and to waste a considerable excess.

A second reason for the use of this excess is one also imposed by the defects of the method. It does, to some extent, check the pulp-staining by holding more thoroughly in solution the gelatinous pectoses. It is a common observation among paper-makers that the more soda used the less is the consumption of bleach.

The best results hitherto obtained by the older method have been round about 26 per cent of soda, calculated on the raw material weight and 16 per cent. of standard English bleaching powder, calculated on the unbleached pulp weight. These we have been able to reduce to 19 per cent and 11 per cent respectively, so chemical cost is now considerable below the best wood-pulp practice. Both sets of figures, for soda and bleach and for both methods, are subject to variations up or down of 1 to 2 per cent, in accordance with the slightly varying analysis of species. There is also a gain of 2 per cent in pulp yield in the fractional system, owing to its less drastic conditions of both digestion and bleaching, and a considerable saving in capital cost of the soda recovery plant. In the overhead system the wash liquors used in leacbing out the spent soda from the digested pulp are staining liquors, and cannot be used again for digestion. They must go to the recovery plant, and as they are of low density they must be concentrated in an expensive multiple effect vacuum apparatus. As a result of the clean cut effected by the fractional method between the staining and the non-staining liquors the wash liquors can be used up in the chain of operations comprised in the regeneration of the recovered soda and the charging of the digesters. Only the digestion liquors need go to the recovery, and these are of sufficient

density to be dealt with by a comparatively inexpensive concentrating and calcining plant.

In factory practice it is not necessary to deal with the starch and pectose groups separately. They can be extracted together by a one to two per cent soda solution—the water deals with the former and the soda with the latter—and the liquor used for such combined separation is preferably that previously used for lignin digestion as long as it contains sufficient free soda to effect the purpose. In quantity this is equivalent, for bamboo, to from 6 to 7 per cent on the raw material weight. The high temperature lignin resolution should, therefore, be conducted with about 7 per cent more than is necessary for the lignin treatment, thus giving it the advantage of high density already alluded to and securing that the residual liquor from the operation shall contain sufficient free soda to effect the pectose resolution in a subsequent charge of raw material. Both operation are, therefore, conducted with one volume of liquor, with obvious advantage to the recovery process, and there is also exhibited that curious property of some colloidal solutions that they are more effective solvents of another colloid than pure solutions. The pectose resolution may with advantage in hastening the process be conducted at temperatures higher than boiling, as long as these do not approach the point at which lignin begins to be affected. As this is somewhere about 130° C., we can safely go up to 120° C.

The figures given above are those resulting from the use of a "straight" soda liquor, that is, one manufactured from carbonate of soda, and of which the essential reagent is sodium hydroxide or caustic soda; but the modification known as the sulphate system is equally applicable to fractional treatment and with results corresponding comparatively for the two methods with those given above. With it the losses during the cycle of operations are replaced by crude sulphate of soda instead of carbonate, and the resulting digesting liquor contains caustic soda and sulphide of soda in the proportions of about three to one. For the overhead method it does possess advantages such as would compel us to use it were we tied to that system. These are :—

(*a*) The sulphide does more effectively deal with the gelatinous pectoses than caustic soda, and so to some extent checks pulp-staining.

(*b*) The sulphide checks to some extent hydrolysis of fibre at high temperatures by the caustic soda and so results in a slightly higher pulp yield.

Its disadvantages are :—

(*c*) Sulphide has little effect upon lignin, and to maintain the quantity of caustic soda necessary to deal with it the combined total of this and sulphide is 2 to 3 per cent more than is required with "straight" soda liquor.

(*d*) Crude sulpbate of soda contains considerably less real alkali than the usual commercial form of carbonate, which is practically a pure article; consequently a larger quantity of the former must be imported at a high freight cost.

(*e*) The objectionable odour it evolves would rule it out in populous districts, though this will probably not apply in the localities suitable for bamboo pulping.

Since fractional digestion effectively gets rid of pectoses before the real digestion, that of lignin, begins, advantage (*a*) is cancelled out and advantage (*b*) considerably reduced in value by the lower temperature at which it is conducted, so the choice between the two is reduced to a question of the relative costs of the actual soda contents of sulphate *versus* carbonate of soda *plus* tbe 2 to 3 per cent alluded to in (*c*). Where freight cost is high the lower soda content of sulphate and the additional 2 to 3 per cent referred to may quite possibly leave the advantage with carbonate, notwithstanding the lower cost of the former at its poin of origin.

It will be evident from the above that our efforts have chiefly been along the line of soda treatment. Considering that bamboo is a grass exhibiting all the characteristic chemical constituents of grasses in general, and especially in the large content of unbleachable starch and pectous matter, it seemed to us that success was more certain along the lines held to be essential with grasses already in use, such as Esparto, and the other standard system of treatment extensively used for wood, known as the sulphite method, has never been seriously proposed for these. But this does not rule out entirely the application of the latter to bamboo, and simultaneously with our efforts an investigation on such lines has been going forward in this country, the digesting liquor being a bi-sulphite of magnesia. It is uncertain if it will result in lower costs than soda treatment, but it will probably succeed in producing a distinctive type of pulp, which will be all to the good of bamboo, as a whole, and reinforce its claims as an alternative to wood-pulp. The latter is produced in about equal quantities by both methods, and each is valued for its distinctive paper-making qualities.

The preparation of bamboo prior to digestion has given rise to some difference of opinion. It is somewhat noteworthy that such differences as exist relate entirely to the practical details of treatment. No difference exists as to the suitability of bamboo for the manufacture of papers requiring high bleaching and printing qualities. As regards preparatory treatment, two schools have arisen, the crushers and the chippers. Reduction to chips is the wood-pulp practice, and its advocates appear to be in danger of a wood-pulp obsession, which renders them somewhat blind to obvious differences between the two materials. They are undoubtedly entitled to make all the argument they can from the fact that crushing expands the volume of the material to nearly double, and, therefore, apparently reduces the capacity and output of the digestion to half that obtainable with chipped material. I say apparently, for the actual result is not quite so bad as that. By reason of its lesser resistance to liquor penetration, crnshed material digests in three-fourths of the time required for chips, so if the output of a digester charged with chips is represented by 15, the output of one charged with crushed material is not 7½, but 10. Further, crushing does not create any additional recurring costs, but merely a greater capital outlay for the additional digesters required. Still, the objection is a valid one, and entitled to full consideration, but we think it is more than couterbalanced by what emerges from a critical study of the physical and constructional features of the two materials, thus :—

(*a*) The fibre bundles of bamboo lie perfectly

parallel to each other with no cross-graining and no interlacing; they split cleanly and crush perfectly without reducing to dust. Wood will not crush without a considerable loss through dust.

(*b*) Bamboo is thickly studded with groups of sap canals, which run perfectly parallel throughout the whole length of the stem. In the dry material these are filled with air, which, being in a state of capillarity, is extremely difficult to dislodge, and, in the case of chips, offers a powerful resistance to the penetration of liquor, besides adding to the buoyancy of the mass and tending to float a portion of it above the liquor. The splitting, which is the first effect of crushing, runs along these canals, which are thus laid open to attack by liquor on their interior surfaces and the capillary air is got rid of. Wood presents no such feature.

(*c*) Baboo, throughout the entire length of stem, is of homogenous one-aged, one-season growth. Wood, if say, 60 years of age, has its heart wood 60 years old, while its outer ring of growth is one year old. Therefore it must contain differences in density and quality, and consequently there must be a proportion of undigested chips in wood-pulp digestion. There is no need for such a must in tbe case of bamboo.

(*d*) The nodes of bamboo, contrary to general belief, are not denser than the internodes. Their specific gravity is about 5 per cent less. But they contain more pectose and lignin and their colloidal resistance to liquor penetration is, therefore, greater. The antidote to this is opening up their tissues completely. By crushing, this can be done so thoroughly that tbey can scarcely be distinguished in the general mass. As chips they must result in a considerable proportion of undigested specks and blemishes in the pulp.

The chipping school, under the influence of their wood practice obsession, are quite reconciled to the presence of this undigested matter in their pulp. They regard it as natural and expend their energies upon means of screening it out of the pulp after it is cooked. The crushers say it ought not to be there at all, that there need be no undigested chips in the pulp except occasional accidentals, due to particles of raw material getting lodged over rivets or otherwise hung up in the upper part of the digester beyond the reach of liquor, and they think this is a result well worth attaining at the cost of somewhat larger digester plant; and they claim further that since crushed material will digest with less drastic conditions of time, temperature and soda, the digestion cost is less and the pulp yield more.

(To be continued).

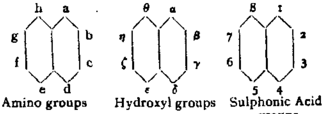
THE RATIONAL NOMENCLATURE OF THE NAPHTHOL, NAPHTHYLAMINE, AND AMINO-NAPHTHOL SULPHONIC ACIDS.

By E. de BARRY BARNETT, B.Sc., F.I.C.

THE importance of the naphthol, naphthylamine, and amino-naphthol sulphonic acids in industry has lead to their being given trivial names. Unfortunately, these names give no clue as to the orientation of the groups present, and are very confusing, as some acids have received as many as three different names, whereas in other cases the same name is used to denote quite different acids. Thus, Cain in "The Manufacture of Intermediate Products for Dyes" (1918), describes two different acids as F-acid, and no less than four different compounds as S-acid. Further, if different authorities are consulted it will often be found that they use different names for one and the same substance.

In order to avoid confusion, the present writer, several years ago, devised a system of nomenclature for his own use which has the advantages of being simple, definite, and at the same time indicating the orientation of the groups present in the molecule. Tbe method has proved to be so useful that it may be of interest to other chemists who have to deal with intermediate products. It may be briefly described as follows.

Each of he eight positions in the naphthalene ring system is denoted by (1) a letter of the English alphabet; (2) a letter of the Greek alphabet; and (3) a numeral. These positions are shown in the accompanying diagrams. The use of letters of the English alphabet is reserved exclusively for denoting the positions of amino-groups, hydroxyl groups being invariably denoted by Greek letters, and sulphonic acid groups by numerals. The words "amino," "hydroxy," "sulphonic," and



Amino groups Hydroxyl groups Sulphonic Acid groups.

"naphthalene" being superfluous, are omitted in building up the names. The following three examples serve to illustrate the method.

2-Aminonaphthalene-6-sulphonic acid (Brönner's Acid) becomes b.6 acid. 1-Naphthol-4-sulphonic acid (Nevil and Winther's Acid) becomes α.4 acid. 1 : 8-Aminonaphthol-3 : 6-disulphonic acid (H-acid) becomes a.h.3.6 acid., or a.θ.3.6 acid. It will be noted that all the names are short and that the positions of the groups are indicated definitely. The names have heen found particularly useful in denoting the structure of the azo-dyes.

It may be urged that the Greek letter "zeta" (ζ) is inconvenient to write. This is true, but it will be found in practice that it is very rarely, if ever wanted.

For the very common acids such as naphthionic acid, R-acid, NW-acid, &c., colour chemists will probably prefer to retain the present names, but for the acids less frequently encountered the above system will be found to be very convenient.

UNIVERSITIES, RESEARCH, AND BRAIN WASTE.*

By J. C. FIELDS, Ph.D., F.R.S.

To the Members of the Royal Canadian Institute.

IT is my desire first of all to thank you for the honour which you have conferred on me by electing me your President for the year now beginning. The two past years have been prosperous ones

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under the Presidency of Dr. J. Murray Clark. Many new members have joined and the attendance at the meetings has appreciably increased. The Institute has carried on its propaganda for research both in regard to its application to industry and on the purely scientific side. In its campaign it has been aided by a succession of eminent lecturers from the United States. The activities of the Institute will continue to be directed by the same policy as hitherto, and I may say that arrangements have been made for a group of exceptionally able men to lecture under its auspices in Toronto during the coming winter.

With your permission I shall now turn my attention to the consideration of the subject which I have selected for my address this evening—"Universities, Research, and Brain Waste."

Whatever the undeveloped resources of a country may be, the greatest of all its resources is the brain of the people, and more especially the brain of the exceptionally gifted. Other resources in fact are made available only by combination with this primary resource. The wealth of the race consists of the thoughts of a limited number of men accumulated through the generations. By means of these thoughts, or certain of them, we are able to reproduce things. It takes no great mental effort to realise that of all the material products of man's hands which existed 50 years ago, that which persists to-day is negligible.

There exists a body of men whose function it is to increase the wealth of the race, to add new thoughts to the fund already accumulated. These are the so-called research workers. Men or research inclination there have been in all countries and in all periods. In recent times, however, the number has increased greatly. Certain universities in America, and a large proportion of those in Europe, regard it as one of their functions to prepare men to do research. Many of the European universities regard it as their chief function.

The research workers are makers of modern history as no other body of men are. The difference between the conditions under which our forefathers lived 300 years ago and those under which we live to-day is due to the research workers. The layman little realises what an influence individual men among these research workers exercise upon his daily life. In ordinary conversation the name of Shakespeare is heard more frequently than that of Newton, and students of the great dramatist will be surprised to be told that Shakespeare as a factor in determining their lives is a bagatelle compared to Newton. The thought of the great scientist, as a matter of fact, permeates our civilisation, and can be traced distinctly in a multitude of conditions which surround our every-day life. To justify our statement, it suffices to refer briefly to Newton's discoveries of the calculus and the law of gravitation. The calculus is the basis of the greater part of higher mathematical analysis. It is the most powerful of all instruments in handling geometrical problems, and it has opened up new territories in geometry which are all its own. What I want more particularly here to refer to, however, is the role which the calculus plays in connection with physical phenomena. Its aid is invoked in questions which relate to motion, light, heat, electricity. The principles of dynamics are formulated in terms of its notation. Unfortunately it has had a share in the development of modern artillery, for the theory of projectiles is an application of the calculus to the law of gravitation. It has had its place in the advances which have brought us the electric light, the trolley, the power house, telegraphy, and telephony, both with and without wire. When we read the despatches and cablegrams in our morning paper we do not pause to remind ourselves that the thought of Newton is one of the factors which has made this possible. No more does it occur to the baseball enthusiast that he is under any debt to Newton when he stands before the newspaper office down town and scans the latest baseball bulletin.

Transportation by sea, by land, and by air, has much for which to thank Newton. The calculus had nothing to do with the invention of the steam engine by James Watt. It has, however, done important service during the last half-century or more in handling problems relating to steam engines and turbines where fundamental principles have been involved. It has had its effect on naval construction. It is involved in the general question of the relation between shape, power, and speed in connection with a vessel. It is essential to the study of the strains and stresses in a ship's members. Navigation, too, depends on astronomical data, the obtaining of which involves the use of the calculus. Our clocks and watches are regulated by data so obtained. It has had its share in the development of the automobile engine. It proves itself useful in problems connected with hydraulic elevators. It played a fundamental role in solving the initial difficulties connected with flight, and later on it was an essential instrument in solving the problem of stability in relation to aeroplanes. It renders valuable assistance in connection with the finding of necessary data for the putting up of large steel bridges and for erecting other engineering structures. Physical chemistry makes extensive use of the formulæ of the calculus. The physiologist, too, when he is confronted with problems in surface tension is forced to call in its aid.

The same god-like instrument enables the astronomer to follow the earth and the planets in their courses about the sun and to keep track of the moon in its more devious path around the earth as the latter whirls about the sun. It renders it possible for him to measure the combined and varying tugs of the sun and moon on the waters of the earth, and with its formulæ he traces the paths of the particles of water that go to make up the tides as they travel across the oceans of the earth. By the aid of this instrument applied to the solar system, on the assumption that it is regulated by the law of gravitation, Adams and Leverrier, led thereto by certain inequalities noted in the motion of the planet Uranus, deduced the existence and location of the planet Neptune and foretold its mass and orbit.

Clerk Maxwell it was who formulated the theory of electricity and magnerism in terms of the calculus. Hertz devised the experiment which verified the existence of certain waves in the ether predicted by Maxwell from his theory, and Marconi utilised these waves for wireless telegraphy. In later times, we have become familiar with X-rays, radio-activity, and the theory of electrons. The physicist studies the relative positions of the atoms in a molecule and going beyond distributes

the atom itself into electrons. He tells us wonderful stories about the energy locked up in an atom, and Sir Oliver Lodge informs us that if this atomic energy were only available, a ton of matter day by day would suffice to supply the needs of Great Britain. Going over from the infinitely small to the infinitely great, that eminent Dutch astronomer and hardy generaliser, Kapteyn, has launched a scheme to study the structure of the universe. His nearest material is over 25 trillion miles away, but his scheme is under way, and he is steaidly accumulating his data. At some stage in the development of all the branches of physical science here referred to, Newton's thought has played a role and the calculus has proved itself a helpful intrument in regions undreamed of by its discoverer.

In what precedes I have touched on the physical sciences and the application of the calculus to them. I have mentioned but a few among the many great names associated with the development of these sciences. I have wished in a few words to do the impossible, to suggest to the layman by an illustration something of the reach and importance of research, to indicate how the work of one research man connects up with that of another, and to shadow forth how intimately the life work of some great thinker may be related to our daily life and activities without our being conscious of the fact. Newton himself, it may be pointed out, was not such an unconditioned being that his work was independent of that of the workers who preceded him. The discovery of the calculus was already a foregone conclusion after Descartes had invented analytical geometry. In the hands of a lesser genius, however, its scope would not have been as fully appreciated, and immediate results would have been more meagre. I wish that I could convey briefly to the laymen in my audience some conception of the nature of the calculus, but this is not within my power to do. That will, perhaps, not be surprising in view of the fact that a hundred lectures are devoted to introducing the honours students in mathematics and physics to the subject in their second year, and that a considerable portion of their time in their third and fourth years is utilised in increasing their appreciation of its scope and application.

In the foregoing I have said nothing about the immense contributions of chemistry to the health, wealth, and comfort of mankind. I have not referred to the debt we owe to biology, botany, bacteriology, geology, and varous other branches of science. I have pointed out the successive dependence of one man's work on another's. I would draw attention also to the simultaneous co-operative character of scientific work. For hundreds of research workers in different parts of the world are at the same time busied on the same problems or on related problems. They keep in touch with one another's work principally through highly specialised journals which the layman never sees. In these journals as a rule the results of their investigations are published. To expedite matters it has been found necessary to devise certain aids. One of these is the International Catalogue of Scientific Literature which, before the war, appeared annually in 17 volumes, each volume corresponding to a separate branch of science. Besides an alphabetical list of authors each volume contains an elaborately classified subject index. This, however, in view of the mass of material being turned out, does not suffice for the needs of the research worker who wants speedy orientation with regard to everything which may have a bearing on his own special line of work. For this something more than a mere classification of titles is needed. Some further indication as to the contents of an article is necessary. The need here referred to is more or less satisfactorily cared for in different branches of science. In physics and electrical engineering, for example, we have what are called "Science Abstracts."

The need of orientation will be better realised by the layman when he is told that the number of titles listed in the 17 volumes of the International Catalogue for the year 1912 was 67,926. The great bulk of the literature here referred to is of research character, and its authors number up in the tens of thousands. The individuals in this army of investigators vary greatly in ability. Many of them are handicapped by the conditions under which they have to work. The products of their efforts are, of course, very unequal. In the aggregate, however, the importance of the activities of the army of research workers to the welfare of the nations can hardly be overestimated. How many of the nations—how many of the individuals who go to make up the nations—realise this fact? How many of our own people appreciate it adeuately?

That does not exist which I do not see is the most prevalent and most disastrous of all fallacies. Every day men in high places act on this fallacy. It shapes important policies and determines great issues. It came very near being the undoing of Great Britain when the opening of the war found her scientifically unprepared, for her statesmen in taking counsel had been accustomed to leaving out of account science which, as it proved, was the most important factor in the situation. It is my own conviction and that of all scientists with whom I have discussed the matter that the modern research movement is the greatest intellectual movement in the history of of the human race. How many Governments act as if this conviction had taken hold on them? In how many of the universities on this continent have those in authority seen the vision?

The natural home of research is in the universities. There most of the fundamental discoveries in science have been made in the recent past. Let us hope that this may continue to be the case in the future. The highest functions of a university are on the one hand to provide place and opportunity for the research worker to carry on and make his discoveries and on the other hand to train young men of selected ability to use their creative faculties. This is more fully appreciated in certain European countries than in America.

In Germany, at least before the war, no man was appointed to a university staff who had not proved himself to be intellectually productive. Once appointed, he could lecture as little or as much as he pleased. He could devote practically all his time to research if he was so inclined. He was relieved of financial worry. He did not need to preoccupy himself with what, under certain eventutlities, would become of his wife and

family. Everything was provided for in advance, so that, with a mind at ease, he could concentrate all his powers on his science. On the instructional side the German university had particularly in mind the student of exceptional ability. It put no obstacle in the way of admitting others. It was not a difficult matter to obtain a degree. The arrangements, however, were made with a view to the needs of the more highly gifted. These were trained to be research workers, and those who distinguished themselves most in research received preferment later on. The intellectually productive men then enjoyed a certain prestige in Germany before the war. This was overshadowed, however, by the factitious prestige attached to the military uniform, and we know how the war-mad militarists of Potsdam prostituted German science and purposed by its aid to subjugate the rest of the world.

In France, perhaps more than in any other country, is intellectual achievement bonoured. An intellectual aristocracy, according to Prof. Le Chatelier, is essential to the French democracy. This means that intellect is trained to the service of the State. In peace times membership in one of the five academies which constitute the Institut de France, a purely intellectual distinction, is the highest honuur to which a Frenchman can aspire. The Institut, it may be noted, through its academies, disposes of considerable sums as rewards for notable intellectual achievements. The Academie des Sciences in particular has a long list of prizes which are awarded from time to time to scientists who have solved specified problems or have made advances along certain lines in Science. Living, the creative thinker is regarded as the glory of his country. When he departs this life his remains are buried in the Pantheon with funeral rites which vie with those accorded to a President of the Republic.

(To be continued).

PROCEEDINGS OF SOCIETIES.

GEOLOGICAL SOCIETY.

June 8, 1921.

MR. R. D. OLDHAM, F.R.S., President, in the Chair.

A DISCUSSION on the "*Relations of the Northern Red Sea and its Associated Gulf-Areas to the 'Rift' Theory*" was opened by DR. WILLIAM FRASER HUME, in the following words:—

(1) The areas specially considered are the northern portion of the Red Sea and a region to which the name of "Clysmic Gulf" has been given. The Clysmic Gulf (from Clysma, the Roman name for Suez) is defined as the district bordering the Gulf, and lying between the (largely) fault-bounded ranges of Egypt and Sinai on the west and the east respectively which dominate this depressed area. Within its borders Miocene deposits are of wide distribution; beyond them, these are notably absent. The folds within this region are from north-west to south-east, outside it their trend is frequently almost a

(2) A line prolonging the direction of the western coast of the Gulf of Akaba to the shores of Egypt divides the Clysmic Gulf from the Red Sea, the former being occupied by the shallow Gulf of Suez and disturbed lowlands, while south-east of the dividing-line is the Red Sea, with its great depths and its narrow coast-line.

(3) The Clysmic-Gulf area is one of complicated fold-and-fracture effects, while in that of the Red Sea only fold effects have been observed.

From a study of the facts known, it is concluded that:—

(4) The whole region under consideration underwent extremely slow submergence, the negative movements continuing from early Jurassic to late Cretaceous times.

(5) This was succeeded by one of a positive nature, the actual emergence of the new land taking place near the close of the Eocene Period. It is suggested that the area was occupied by an anticline or anticlinorium plunging northwards in the Clysmic Gulf region, and that it was subject first to marine and then to subaërial erosion. This formed part of the continent on which grew the trees of the Petrified Forest, and on which wandered animals such as the *Arsinoitherium* and the earliest elephants. This continental period was most marked during the late Eocene and early Miocene times, and the area dealt with here appears to have become one of very varied ridge and depression.

(6) The whole region thus dissected was invaded by the ancient Mediterranean; the slow advance southwards occupied the main portion of the Miocene Period, and probably extended well into the Pliocene. The pre-existing ridges became coral-reef centres: the intervening depressions were filled up, first by land-derived deposits (such as conglomerates and clays), and then by lagoon formations (gypsum and salt). The earliest of these formations appear to have been of Schlier (Middle Miocene) age.

(7) The sequence of events from Middle Pliocene times onwards is difficult to unravel. The whole region of the Clysmic Gulf became folded and fractured to a remarkable extent, there being certain underlying elements of order discernible. There is strong faulting at the borders with the igneous hills, and fold-ranges are well marked, these being of a symmetrical anticline type. It is suggested that compression of the area, with uplift of portions of it, offers the best solution for the facts observed. It seems difficult to conceive that dislocation so marked, spread over so wide an area, could arise under rift formation as defined by Prof. J. W. Gregory. It seems equally difficult to ascribe the whole of the surface-differences to erosion alone. It will be readily understool that no simple solution of the problem can be offered on the evidence at present available, especially in view of the fact that no important faulting has been noted on the western borders of the Red Sea.

(8) The same reserve must be exercised with regard to the very interesting eroded trough-fault valleys, which the writer formerly regarded as of rift origin.

(9) A suggestion is made that the portion of the Nile Valley about lat. 26° N., where faulting is most conspicuous, may have been initiated by erosion of a sharp anticlinal fold due to the compression of almost horizontal strata. Sharp

folds exist in the desert east of the Nile, but their origin is at present doubtful.

DISCUSSION.

The PRESIDENT said that it had been customary of late years to devote at least one meeting in the session to a lecture on some subject of interest to geologists, or to a discussion of one of the larger and more speculative problems of geology. The subject selected for discussion that evening might be briefly defined: there was in Central Africa a well-known surface-feature, for which Prof. J. W. Gregory had popularised the name of the Great Rift Valley; there was also, in Southern Syria, a similar surface-feature, occupied in its northern part by the Jordan Valley, and continued as a surface-depression to the Gulf of Akaba. According to one school of thought, these two surface-features were not only of similar genesis, but formed the extremities of a continuous surface-feature, intimately related in origin to the tectonics of the surface-rocks, called the African Rift Valley, of which the Red Sea was regarded as an integral and important section. According to another school, no such continuity is recognised, and the origin of the Red Sea is attributed to causes other than those which gave rise to the rift-valleys of Africa proper and of Palestine. Dr. Hume had had a large personal experience of the geology of the Red Sea region, and his presence in England afforded a useful opportunity of raising a discussion of this important and interesting problem.

Col. H. G. LYONS expressed his great interest in the information that Dr. Hume had laid before the Society, which made the structure of this part of North-Eastern Africa much clearer. He agreed that former assumptions of the rift character of the Nile Valley were not tenable, and that the Gulf of Suez, too, could not be strictly described as a rift-valley. For the Red Sea, he asked whether more information had been collected of late as to the structure of the eastern shore, to show whether it was as free from fracture-lines as the western was, according to Dr. Hume's account.

Prof. J. W. GREGORY, in a letter sent as a contribution to the discussion, remarked that the agreements between Dr. Hume's views and his own were more essential than the differences. The sequence of events stated by Dr. Hume for the Clysmic Gulf is similar to that which he had adopted for the Rift Valley as a whole—including Jurassic subsidences due to the Mesozoic deformation of the crust, an Eocene land over the Red Sea, subsidence of the Rift-Valley trough in the Oligocene, renewed and extended especially in the late Pliocene Period. The Gulf of Suez is not typical of the Rift Valley, as its lines there intersect those of the Levant, and as the rocks traversed are mostly young stratified deposits.

The main difference between the writer's interpretation and that stated by Dr. Hume is the relative importance of fold and fault. The importance of the faults is indicated by Dr. Hume's remark that "the (largely) fault-hounded ranges dominate this depressed area," and by his statements (*Geol. Mag.*, 1910) regarding the dome over the Clysmic Gulf: "I can conceive of no erosive agent which would break across this great earth-feature without the intervention of fracture [and that] "faulting, and faulting alone, can explain the phenomena." These conclusions are supported by the recent statements in bulletins by the Geological Survey of Egypt that faulting was "the controlling factor in the formation of the shore line of the Gulf" [and in] "determining the present position of the Gulf of Suez."

The attribution of the Red-Sea section of the Rift Valley to folds appears to be due to the use of the term "fold" for movements which the writer regards as faults. The Geological Survey of Egypt has recently explained its use of the word "fold" by a diagram (*Petrol Res. Bull. No.* 6, 1920, sketch before p. 1) which identifies a steep, plane, slickensided surface as a fold. The writer regards the movement shown by this diagram as a fault, so that the difference is a question of terms. He found it impossible, in view of the post-Eocene faults with fault-breccias beside the Gulf of Aden and the maps of the Egyptian Geological Survey at the other end of the Red Sea, to accept the view that that on the Red Sea only fold-effects have been observed. He agreed that the Lower Nile Valley is not a Rift Valley, its structure being the antithesis to that of the Red-Sea trough.

With regard to the length of the Rift Valley, he referred to the explanation in his forthcoming book, "The Rift-Valleys and Geology of East Africa" briefly stated in *Geogr. Journ.*, lvi., 38), representing it as due to world-wide mid-Kainozoic earth-movements, and to its position between the mountain-forming movements in Europe and Africa which were northward, and the simultaneous Asiatic movements which were southward. Its great length is due to the continental scale of the accompanying movements, and seems no more inconsistent with its formation by tension than the equal length of the contemporary fold-mountain system is inconsistent with their formation by compression.

Dr. J. W. EVANS thought that the structure of the Akaba and Clysmic gulfs would prove very different, the latter being probably the same as that of the Dead-Sea depression. He enquired whether the faults shown in Dr. Blanckenhorn's map near Suakim, parallel to the coast in that neighbourhood, and approximately parallel to the Gulf of Akaba (though not in the same line), were authentic, and, if so, whether they had a downthrow towards the sea. The deep depression in the north of the Red Sea was sharply defined, both on the north and on the south, and suggested a subsidence. The existence of a "graben" seemed to point to a state of tension, when it was found, but did not imply the existence of a rift as wide as a sunken area. The speaker looked forward to the production by the Egyptian Survey of further evidence on this most important question.

Mr. G. W. LAMPLUGH remarked that the "rift-valley hypothesis raised the wider question as to the supposed prevalence in many parts of the world of large-scale surface-features produced directly by comparatively recent faulting. The geological record showed that the local development of troughs of depresession had been frequent throughout the accumulation of the stratified rocks; and the resultant synclines were often faulted longitudinally at the margins, as well as within. But the field-evidence generally implied that the subsidences had been gradual, and the faults of slow growth. Secondary "fault-controlled" features, due to selective denudation, were common enough both in valleys and on high

ground, but new orginal fault-scarps were difficult to find; he had not yet himself seen a single convincing example, though he had seen several to which this origin was ascribed. He knew no case of the trunk-drainage of a land-area having been *revolutionised* by the uprise of a fault-block athwart it; and this seemed to imply that the surface-effects of faults for a long time past had never been rapid enough to overcome the ordinary course of weathering and erosion. The conception of the "rift-valley" had always been attractively simple, and there may be features on the earth to which the conception will apply absolutely; but the researches of Dr. Hume and his colleagues have shown that we must now look elsewhere than in Egypt.

The PRESIDENT said that the interesting and instructive discussion had left two doubts in his mind still unsatisfied. One was whether two distinct problems, the origin of rift-valleys and the origin of the Red-Sea depression, had not been confused. The magnitude of the Red-Sea depression was of so different an order from that of the African rift-valleys, that any similar rifting, which may have taken place, would be of subsidiary importance in determining the position and form of the Red Sea. The other doubt was as to the existence of anything which could properly be called the Great Rift-Valley. There was in Africa a belt of country in which the surface-form known as a "rift-valley" was of fairly frequent occurrence; but it seemed to him that there was insufficient evidence of continuity between them, or of the existence of one continuous rift-valley. It appeared more likely that further investigation would prove the independence of the individual depressions, which should rather be regarded as separate members of a continuous range or series.

Dr. W. F. HUME, in reply, thanked Col. Lyons for his remarks, and pointed out that Dr. Blanckenhorn had never himself visited the Red-Sea region, the faults inserted having no basis of observation. With regret it had to be stated that Dr. Blanchenhorn was frequently incorrect in regard to the existence of faults in Egypt. He had bordered the Fayûm with faults and then removed them, shown an important one at Moghara Oasis which could not be confirmed, and finally bordered the Red Sea with faults where proof of their existence was absolutely wanting.

Prof. Gregory was certainly justified in stating that the actual diagram exhibited was a true fault; but, if continued, it passed into a monoclinal fold. The point did not affect the main issue, as the section was within the area of admitted fracture.

Instead of assuming all the depressions discussed as part of a great Rift system, each had to be considered on its merits. The parallelism of the Red-Sea borders could be explained as due to erosion of a broad fold, and, apart from the apparent absence of faulting on the large scale along its borders, the breadth of that sea was such as to make it most difficult to conceive it as a tension-crack. In the Clysmic-Gulf area, which was narrower, and lying between hill-masses of granite or limestones, folding and fracture were intensely marked, but might well be due to compression. The features on which special attention would have to be concentrated in connection with rift questions were the relatively narrow valleys of the Jordan, the Dead-Sea depression, and those of South-Eastern Sinai, for which no simple erosion theory seemed satisfactory. They were undoubtedly, like the Clysmic Gulf, fault-guided or fault-controlled depressions. The speaker, as a result of his own studies, agreed with Mr. Lamplugh that a dogmatic assertion of rifts at this stage might give a bias to younger geologists which might cloud the truth, this being one of Dr. John Ball's objections to Prof. Gregorys' original paper.

Dr. Hume also was glad to note the President's remarks, and thought the idea of "tension regions," as advocated by Dr. Evans on this occasion, was one to be approached with great caution, as it required very full experimental evidence.

CORRESPONDENCE.

QUATERNIAN SERIES* AND ISOTOPES.

To the Editor of the Chemical News.

SIR,—In considering the new individual atomic weights involved by reason of isotopes, it is of possible interest to examine some of the earlier speculations to see whether any symmetrical relations are possible. To this end (more as an illustration as to the importance of reviewing past work) the following scheme may be taken as an example. The readers of this Journal will, no doubt, remember my many attempts to work out the individual values for isotopes—these efforts dating back to 1914.

Making use of some of these values, and introducing Aston's experimental values for isotopes in heavy-face type, the arrangements here shown explain themselves.

The original scheme was:—

	At. wt.	Differences.	
Ar=	39·9		
		−16	
Fe=	59·9		−8
		−24	
Br=	79·9		−4
		−28	
Ag=	107·9		

Considering isotopes, the scheme becomes:—

Lower mass isotope.				Higher mass isotope			
Ar=	**36**			**40**			
		18			16		
Fe=	54		7	56		9	(7+9=16)
		25			25		
Br=	**79**		3	**81**		5	(3+5= 8)
		28			30		
Ag=	107			111			
		71 (or 107-36)			71 (or 11-40)		

It is of interest to note that Aston has succeeded in determining the isotopes of nickel, the values being 58 and 60 (see *Nature*, June 23, 1921). This, of course, has no direct bearing on the above, except to strengthen the strong tendency of isotopes to occur in pairs, *i.e.*, as regards species.

Schemes of the kind herein shown must be regarded as uncertain, since surprises are generally in store; but, so far as can be judged, the argon values seem to fit in very well with the others, though the difference between the mass values in this case is *four* units instead of *two*, as in the case of bromine.—I am, &c.,

F. H. LORING.

* See CHEMICAL NEWS, 1909, c, p. 37.

ETHYLSTANNIC ACID.

To the Editor of the Chemical News.

SIR,—In the May issue of the *Journal of the Chemical Society* there appears an interesting paper by Mr. J. G. F. Druce, dealing with a newly-discovered acid having a formula $C_2H_5O.SnO.OH$. In the course of this paper reasons are adduced for regarding the substance as a compound of *stannous* tin; but apparently the author fails to be convinced by his own arguments, since he names the substance "ethylstannic acid."

The contention that "a rose by any other name would smell as sweet" sometimes put forward in excuse for a lax terminology, is, to my mind, very misleading. Exact and precise ideas need for their expression terms equally exact and precise, and it is with the development of such ideas, surely, that science is concerned.—I am, &c.,

H. STANLEY REDGROVE, B.Sc., F.C.S.

CHEMICAL NOTICES FROM FOREIGN SOURCES.

Comptes Rendus Hebdomadaires des Séances de l'Academie des Sciences. Vol. clxxii., No. 26.

"Photographs of the Planet Venus."—By M. F. Quénisset.

"Action of Boric Acid on Glycerol and Polyvalent Alcohols. Application of a new Physico-chemical Method."—By M. René Dubrisay.

"Ammoniacal Silver Carbonate."—By MM. Dervin and Olmer.

"The Parts played by Gaseous Impurities in the Catalytic Oxidation of Ammonia."—By M. Eugéne Decarrière.

"Influence of Forging on the Toughness of Steel."—By M. Eugéne-L. Dupuy.

NOTES.

BOARD OF TRADE ANNOUNCEMENT.—The Board of Trade announce that by an Agreement made with the German Clearing Office, now awaiting the approval of the Reichstag, the time for lodging claims with the British and German Clearing Offices by their respective nationals under Article 296, Section III., Part X., of the Treaty of Versailles, has been extended to September 30, 1921. No further claims under the above Article will be accepted after that date by the Clearing Offices concerned.

AN announcement has been made to the Académie des Sciences by Baron Edmond de Rothschild of his intention to devote the sum of 10 million francs to the foundation of a laboratory of scientific research, to be chiefly devoted to the development of physical and chemical science.

THE British Cast Iron Research Association has obtained a licence under Section 20 of the Companies' (Consolidation) Act, 1908. *President*—The Right Hon. Lord Weir of Eastwood, P.C., D.L., LL.D. (Glasgow). *Secretary* — Thomas Vickers, Central House, New Street, Birmingham. We have a pamphlet giving particulars of the Association, together with the objects and the history of the movement, and inviting application for membership. The cast iron industry is of great national importance, as nearly every other industry in the country uses its products. It should, therefore, possess the strongest and most progressive Research Association in the country. With the support which its importance deserves, this should be readily accomplished. Every individual firm engaged in the production of cast iron should consider that it is to their vital interest that the Association should have their practical support, because the result of its work must necessarily mean that the foundries who are members will be in a position to deal with foreign or any competition on better terms than at present by the reduction in cost of manufacture, by impovements in the quality of castings, and the output should be greatly increased by the simplification of processes and the analysis of materials used.

MANUFACTURE OF SUPERPHOSPHATES. — H.M. Charge d'Affaires at Montevideo reports to the Department of Overseas Trade that by a Bill recently sanctioned by the Chambers, the Institute of Industrial Chemistry is authorised to expend the sum of $60,000 on the construction and installation of a factory of calcium superphosphates, and the extension of the sulphuric acid plant. A yearly expenditure of $1,000 for a period of three years is also authorised for purposes of propaganda, and experiments with superphosphates as fertilisers. On the promulgation of the law in question the exportation of bones, &c., will be subject to a duty of $8 per 1000 kilogrms., and should necessity arise, the exportation of such articles may be prohibited.

WE have received a copy of *Le Verre*, Revue Mensuelle des Industries et du Commerce due Verre. The paper, under the direction of A. O. E. Gobbie, contains all information connected with the glass industry in Belgium. The London publishers are Messrs. Gordon & Gotch, Ltd., 15, St. Bride Street, E.C.

AN announcement has recently been made that the following French radio engineers have been nominated Chevaliers of the Legion of Honour for their inventions: J. Bethenod (high-frequency alternators); E. Bloch (applications of vacuum tubes to radiotelegraphy); L. Bloch (applications of vacuum tubes to radiotelegraphy).

FOR the first time, so far as is known, wireless telephony has been used to transmit services from one church to another in order that a congregation without a regular pastor could have the benefits of Sunday evening worship. The churches involved in this test were the Calvary Episcopal and the Herron Avenue Presbyterian, both of Pittsburg, Pennsylvania, U.S.A., and for several months past the Sunday evening services of the former church have been broadcasted by radio from a test station in East Pittsburg. The arrangements were made by the Westinghouse Electric & Manufacturing Co. For reception, a loop antenna, amplifier, and condenser, was placed on the rostrum in front of the pulpit. The loud speaking horn rested directly on the pulpit. The music, singing, and sermon were clearly received in the second church.—*Radio Review*, July, 1921.

Contribution to the Study of the Acid Constituents of the Resin of the Maritime Pine. Isomerisation of the Pimaric Acids.—M. G. Dupont.—Abietic acid, the chief constituent of various resins, is not a pure body, but a complex mixture of isomorphous acids only one pure constituent of which has been hitherto separated, by Schultz. These acids not existing in the resin, but being the result of isomerisation by heat of the pimaric and sapinic acids, it is logical to endeavour to obtain pure abietic acids from their mother acids. In a previous paper, M. Dupont explained how he decomposed pimaric acid into its two constituents, dextropimaric acid and levopimaric acid. In this note he studies the products of isomerisation of this latter acid.—*Comptes Rendus*, May 30, 1921.

Palm Oil for Motor Cars.—Experiments have made with a view to substituting palm oil for mineral oil in the French colonies, for internal combustion engines. These trials were very conclusive although fouling of the engines was to be feared. The motor was started with mineral oil, and when sufficiently heated, palm oil was substituted. This new fuel may have great influence on the utilisation of the soil in colonies where there is no mineral fuel. The calorific power of palm oil is 9228 calories.—*Industrie Chimique*, May, 1921.

Phenylurethanes of Terpenic Alcohols.—According to Mr. Weehuizen, it is advisable, when preparing phenylurethanes of terpenic alcohols, to employ as agent of dilution boiling petroleum, at 170° to 200° C., and work during boiling. Phenylurethane crystallises in cooling. He thus prepared borneol phenylurethanes, fusion point 137°—138° C.; menthol, fusion point, 111°—112° C. The same method was applied to eugenol and thymol. With a mixture of camphor and borneol the latter is well separated in form of phenylurethane.—*Industrie Chimique*, June, 1921.

NEW COMPANIES.

The under-mentioned particulars of New Companies recently registered are taken from the *Daily Register* compiled by Jordan & Sons, Limited, Company Registration Agents, Chancery Lane, W.C.2.

Union Oils & Bitumen Co., Limited.—(174521)—Registered 27th June, 1921. Reliance Works, George Street, Smethwick, Staffs. To carry on the business of Manufacturers of Bitumen, Paints, Varnishes, Tar Products and Chemical Compositions. also Refiners and Blenders of Oils. Nominal Capital: £2,000 in 2,000 Shares of £1 each. Directors: G. H. Shakespeare, Oakhurst, 56, Lodge Road, West Bromwich; W. F. Edge, 17, Westbourne Road, Edgbaston, Birmingham. Qualification of Directors: £100. Remuneration of Directors: £25 each.

Crusader Reviver Company, Limited.—(175506)—Registered 1st, July, 1921. Langham Place, Northampton. To acquire and carry on the business of Manufacturers of Inks, Stains, Dyes and Preparations for Polishing. Nominal Capital: £1,000 in 1,000 Shares of £1 each. Directors: W. L. Simmons, 135, St. Andrews Road, Northampton; R. Barratt, 11, Birchfield Road, Northampton; G. Pragnell, 134, St. Andrews Road, Northampton; W. H. Henton, 30, Stimpson Avenue, Northampton; C. D. Henry, 22, Bostock Avenue, Northampton. Qualification of Directors: 100 Shares. Remuneration of Directors: To be voted by Company.

Babette, Limited.—(175497)—Registered 1st July, 1921. To carry on the business of Manufacturers of Toilet Creams and other Preparations. Nominal Capital: £300 in 12,000 Shares of 6d. each. Directors: To be appointed by Subscribers. Qualification of Directors: 1 Share. Remuneration of Directors: To be voted by Company. Subscribers: E. J. Burrows, 29, Lyndhurst Road, Highams Park, Chingford, E.4.; S. Humphreys, 19, Richmond Road, East Finchley, N.2.

New Patents.

This List is specially compiled for the *Chemical News* by Messrs Rayner & Co., Registered Patent Agents, of 5, Chancery Lane London, W.C.2., from whom all information relating to Patents Trade Marks and Designs can be obtained gratuitously.

Latest Patent Applications.

17058—Barton, G. V.—Apparatus for manufacture of lead oxide. June 22.

16526—Wolfes, O.—Process for preparation of Tropinone-monocarboxylic acid esters. June 15.

16248—Officine Elettrochimiche Dr. Rossi.—Drying or eliminating water vapours and nitric or nitrous acid vapours from gases derived from oxidized ammonia. June 13.

Specifications published this Week.

164762—Weizmann, C. and Spiers, H. M.—Fermentation of starchy material for the production of acetone and butyl alcohol.

164785—British Dyestuffs Corporation, Ltd., Green, A. J. and Porter, J. W.—Process of manufacture of phthalic acid and anhydride.

164803—Miersch, W.—Method of obtaining hydrofluoric acid from the sulphonating mixtures of organic sulpho acids and calcium fluoride.

145524—Akt-Ges. Fur Anilin Fabrikation.—Manufacture of cellulose esters of organic acids.

149688—Kuh, E.—Process for the production of neutral alkyl esters of sulphuric acid.

Abstract Published this Week.

Gas Manufacture.—Mr. H. Nielson and Mr. J. R. Garrow of 13, Firs Avenue, Muswell Hill and 30, Vineyard Hill Road, Wimbledon, both in London, have obtained a Patent No. 162459 for an improved plant for the distillation of carbonaceous material by contact with hot producer gas. A number of producers are used to consume the whole of the coke obtained, and only one producer delivers gas to the retort so as to avoid undue dilution of the coal gas, prior to the separation of tar oil. The coal is fed into a rotary retort, and the coke is discharged through an annular casing to a conveyor feeding the producers. The gas from a producer passes through the retort to a condenser and oil washer, and thence to an ammonia washer, to which the gas from auxiliary producers is led directly by a main.

Messrs. Rayner & Co., will obtain printed copies of the published specifications and will forward on post free for the official price of 1/- each.

NOTICES.

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FOR SALE.—Laboratory Drying Appartus, Water, Steam and Air Ovens. Steam Vacuum Drying Oven, etc. Particulars from W. Boyle, Widnes.

VACANCY for Assistant Chemist will occur in August at Admiralty Inspection Laboratories, Holton Heath, salary non-pensionable and subject to bonus; present value £363 by £16 annually to £465. Qualification required equal to that of Associateship of Institute of Chemistry with sound knowledge of technical analysis, preferably of explosives. Applications stating qualifications and experience by letter to Inspector of Naval Ordnance, Holton Heath, Nr. Wareham, Dorset.

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PAPER-PULP SUPPLIES FROM INDIA.*

By WILLIAM RAITT, F.C.S.
Cellulose Expert to the Government of India, attached to the Forest Research Institute, Dehra Dun, India.

(Concluded from p. 33).

In proceeding now to review the economic side of the matter, let us disclaim at once any intention of basing estimates upon the present values of chemical wood-pulp. These are about £35 to £45 per ton c.i.f. at British ports, according to quality, and undoubtedly represent temporary inflation. Any attempt to arrive at what may be the normal price of wood-pulp in this country when inflation has been worked off can only be a more or less intelligent appreciation of events, but considering that costs of production for labour, fuel, chemicals, machinery, freights, and wood are three to four times what they were in 1913, and that these advances are probably permanent, with wood still tending to rise, we shall not perhaps be far wrong in putting it at £28 per ton. If this is considered too high, the sequel will show that it is a figure permitting of considerable variation downwards. On similar grounds we would put the future normal price of mechanical wood-pulp—which is not cellulose at all, but only ground raw wood—at £16 per dry ton. Under the transport conditions I will describe later, bamboo can be delivered at manufacturing sites in Burma at a cost of 12s. 6d. to 15s. per dry ton, equivalent to from £1 11s. 3d. to £1 17s. 6d. per ton of unbleached pulp. Compare this with the like cost for wood-pulp, which is from £10 to £12.

Manufacturing charges, inclusive of liberal allowances for depreciation of plant and contingencies, will be under £10 per ton of pulp, so that the total cost on board steamer in Burma ports will probably not exceed £12 per ton—about the cost of raw material alone in the case of wood-pulp. In freights, of course, wood-pulp, being nearer has the advantage, though not proportionally to distance, since port and terminal charges, no inconsiderable proportion of the whole, are the same for any distance. At present, from Burma ports, they are about £6, but this is abnormal, and I am advised on good authority that the eventual normal figure will not exceed £4. The prospects, therefore, are that bamboo unbleached pulp can be delivered in this country at a cost not eceeding £16 to £18. Freights, again, are not entirely a matter of export in this country. There is a growing demand for India, China, Japan, and Australia, and to these countries freights would be in favour of bamboo-pulp and against wood-pulp. The economic position thus disclosed has an interesting relation to mechanical wood-pulp, for which we have assumed a future normal value of £16 per ton. I do not think it has ever been seriously suggested before that a chemically-prepared pulp could be brought within competition distance in cost with a mechanical one, but the figures given above do now suggest such a possibility, and it is not wholly a question of price. Mechanical pulp will not produce a useful paper by itself, and it adds nothing to the quality of a sheet. It is merely a convenient filler, make-weight, and reducer of cost, and must be held together by a considerable admixture of true cellulose. No paper-maker uses it because he loves it, but solely because he *must* to get his cost low enough, and he will willingly substitute for it a true cellulose if it does not cost him very much more, especially since he is well aware that such a substitution enables him more effectively to use fillers, which are cheaper even than mechanical pulp, such as that good old stand-by, China clay.

Few industries are more sensitve to transport conditions. Including the product, six tons has to be transported in and out of a factory for every ton of product where coal is available. If wood fuel is used, the total will be 8½ tons. It does not necessarily follow that each of the primary materials required—which are bamboo, fuel, limestone, and imported soda—must be available under ideal transport conditions. It may be the case that some extraordinary advantage in one of them enables the manufacturer to raise his cost limit for another, but it is evident that next to the raw material, transport is the ruling factor. Its importance may be illustrated by my own recent experience. During the past eight years I have been asked to revise some sixteen propositions for establishment of factories. Of these, only three failed on account of defects in the raw material supply, nine had to be rejected on transport conditions, and only four satisfied all requirements. Judging from enquiries I receive, this phase of the question receives little attention, and a sufficient supply of raw material appears to be popularly regarded as a satisfactory foundation for the industry.

In a previous paragraph I made a statement to the effect that India and Burma could produce ten million tons per annum under *possible* manufacturing conditions—possible, that is, with a normal value of £28 per ton in England—but the areas included in such a survey are naturally capable of being divided into best and second-best, and the best are probably not more than a fifth of the whole. They are to be found chiefly in the coastal belt of Burma and North-Eastern Bengal and Assam, with a smaller area in South-West India. I have myself explored a considerable area of the coastal region of Burma, where the transport conditions are nearly ideal—numerous rivers, many of them tidal to 100 miles from the sea, and with good rafting water above that intersected with creeks and connecting channels, and down which bamboo, felled upon their banks, can be floated to the manufacturing sites on deep water, or within easy reach of ports and anchorages by the aid of lighters. If wood fuel is not available—and it frequently is—coal from Calcutta or oil from Rangoon can be had, and limestone, also by water, exists at several places on the mainland or islands close to the coast. The only foreign import required carrying a high freight cost is the small amount represented by 15 to 20 per cent of the total soda consumption.

There is one peculiar feature of bamboo as to

*From *Journal of The Royal Society of Arts*, June 24, 1921. (By permission).

*which a warning should be issued, viz., the extra*ordinary phenomenon it exhibits of cyclical gregarious seeding and death. A few species do follow the usual rule of grasses in annual seeding, and a few others seed sporadically, but most of the important ones flower in cycles of long period and gregariously, and each species has its own length of cycle. It goes on reproducing itself by shoots thrown up from the root year after year for 20, 40, or 60 years, until, feeling old age approaching, it throws *all* its remaining energies into producing an enormous crop of seed, and then dies. The new generation, although ultimately destined to produce culms which may be 120ft. in length, and 6in. in diameter at the butt, throws up a first crop of diminutive stems, perhaps 18in. high and less than a ¼in. thick. Next year brings a crop somewhat larger, and so on, increasing year by year in strict proportion to the growing power of the plant to produce starch and store it in its roots, until, after from four to ten years—the period varying with species, soil, and climate—it is again throwing up its full-sized culms. Note also, as a striking example of Nature's silent dynamic, that these stems which, as I have said, may be 120ft. by 6in., are produced of full height and diameter in four months. It is one of the few plants which you can literally see grow. Its branch and leaf system are developed in its second season, and it is then fully matured.

It will be clear from this that a factory planted in a district without some enquiry having been made as to the seeding cycle, might find itself suddenly bereft of supplies for a prolonged period. There are two methods of insuring against this; first, the next seeding period may be known to be at such a date that supplies can be depended upon for a period long enough to secure an ample return on capital invested in the undertaking, and, second, the presence in the area of an alternative species which, as is invariably the case, does not flower at the same period. It is satisfactory to be able to add that most of the important species have seeded within recent years, or are now in process of doing so, as if Nature had anticipated the demands we are about to make.

The crisis now threatening the paper industry, and, it may be added, the large and increasing family of industries based on cellulose, of which artificial silk and celluloid are types, is no unprecedented experience. It is historic and oft repeated. Beginning with the failure of rag to provide for a continually increasing demand, the trade during the last 100 years has passed in succession through the phases represented by the utilisation of textile wastes, straw, esparto, and wood, each in turn hailed as salvation, and each in turn failing to cope with the requirements or finding a better market. It remains a fundamental axiom of the industry that it is a "picker-up of unconsidered trifles." As the interests of other manufactures in a material increase so in proportion that of the paper-maker decreases. They can all pay more for it than he can. I have been trying for 25 years in various parts of the world to find a solution for this recurring trouble. As the final considered result of that experience, I venture to express the belief that no permanent solution of it can be found, except in the vast stores of annual—and I lay much stress on the annual—products of the forests and waste places of tropical and sub-tropical regions. Enormous in their volume, frequently co-existing with splendid transport and manufacturing facilities, continuous and rapid in their natural reproduction and easily converted by modern methods, they provide a field of enterprise of which we may well hesitate to prophesy the expansion and wholly fail to see the end. And remembering recent experience when we found ourselves almost wholly dependent upon foreign supplies, may we be pardoned for uttering a little pæan of congratulation that such areas are within the Empire?

DISCUSSION.

Mr. SINDALL then contributed the following observations: Mr. Raitt, in his address, shows that with regard to the preparatory treatment of bamboo for ultimate conversion into paper, two rival schools are in existence, which he describes as the "crushers" and the "chippers." The argument on behalf of the crushing school has been exhaustively presented, and it would, therefore, be interesting to know the line of argument adopted by the "chippers," so-called.

In this case, the stems of bamboo are passed through a special slab-wood chipping machine, which cuts the bamboo into small chips similar to those obtained by the treatment of slabwood. It is stated that such a process gives a much greater capacity in the digester, with a closer and better packing of the material. The digester is more easily and quickly filled, and owing to the closer packing of the material, less liquor is required. This, in its turn, means the use of a stronger liquor, and ultimately a much smaller quantity would need to be evaporated for the recovery of the soda. Messrs. Boving & Co., who have developed this system, state that they are able to fill a digester of a capacity of six tons by blowing in the chips in about half-an-hour. Experiments were made by them in Sweden on a large scale, some 20 tons of bamboo having been utilised for the purpose, and it has been proved that the product obtained is perfectly satisfactory.

This firm have given considerable attention to the question of economy in the production of esparto and bamboo pulp, and are at the present moment engaged in the erection of a large esparto plant in Scotland, based in the most modern practice of pulp treatment and the methods being introduced are certainly worthy of close attention on the part of paper-makers. The system as devised introduces many ingenious methods for economy in fuel and labour. The material is cut into small pieces, cleaned and dusted, and then blown into the digesters. The requisite amount of caustic soda is run into the digester, and the cooking proceeds by a new system of circulation. In present practice the material is cooked by blowing live steam into the mixture, with the result that the consequent condensation of the steam increases the volume of the liquor to be evaporated for the recovery of soda. In the new system the liquor is passed through the grass in the digester through an outside circulating system heated by high-pressure steam in such a manner that the steam condensed is drawn off separately and utilised for heating washing water or cooking liquor. The volume of liquor in the digester in this case is not increased and a definite saving is thus effected.

It is proposed to utilise this condensed steam for heating up the cooking liquor so that the pulp is at once supplied with hot liquor and this again means economy in steam.

When the pulp is sufficiently cooked, the pressure in the boilers is utilised to discharge or blow out the boiled grass direct to the washing tanks or diffusers. This method is substituted for the present system of allowing the steam to blow out into the air or into water. The practical result is that the black liquor containing all the non-fibrous organic compounds present in the original esparto has a density of something approximating 14° to 16° Twaddle as opposed to 6° or 8° Twaddle.

The clean pulp is flushed out of the diffusers by water, and passed over screens and sand traps similar to those employed for the production of wood pulp.

The whole process is continuous, requiring very little attention, and appears to be a great advance on the present system.

The same plant can be used and has been carefully designed for the treatment of bamboo. It appears that the knots in bamboo offer no difficulty, and certainly results obtained on such a large scale as that involved in the treatment of 20 tons should afford sufficient evidence as to the value of the method designed by them.

The most important development, however, in connection with esparto, bamboo, and similar materials such as Indian grasses, is the treatment of the black liquor obtained during the process of digestion. When these materials are treated with caustic soda, some 45 per cent to 50 per cent of the original matter is dissolved and the liquor is then highly loaded with organic matter.

In the earlier days of paper making this liquor was discharged into open streams and rivers of the neighbourhood, but owing to the action taken by local authorities it became necessary to devise some method of dealing with this black liquor, the discharge into streams and rivers being forbidden. A method was found in a process by means of which the liquor was evaporated to a thick consistency, in which condition the mass would catch fire and could be burnt, the organic matter in solution acting as fuel for a more or less complete incineration. The organic soda compounds were thus converted into crude carbonate of soda, in which form, after boiling with a definite proportion of lime, it was re-converted into caustic soda. The methods of evaporation, economy of washing water and scientific control of the several stages of treatment were gradually improved, and the recovery process, at first regarded as the outcome of a mere whim on the part of obnoxious local authorities, soon revealed itself as an important factor in reducing costs of production.

Of recent years, considerable attention has been given to a more scientific method of recovery in the hopes of obtaining more valuable bye-products than combustible matter. Rinman's process for the conversion of the soluble organic constituents into definite bye-products of commercial utility, already well established for wood pulps in Sweden, has now been applied in these recent experiments with bamboo, and an estimate of bye-products available from a standard bamboo pulp mill having a capacity of 10,000 tons air-dry pulp per year (using 22,000 raw material) is as follows:

Bye-products.	Estimated kilos.	Price per kilo.	Total price.
1. Methyl alcohol ...	388,000	3s.	46,200
2. Acetone used as petrol &c.	330,000		
3. Ethyl-methylketone (petrol)	22,000	1s.	38,500
4. Light oils (petrol)	220,000		
5. Heavy oils (Diesel oil)	572,000	5d.	11,917
	1,650,000		£96,617

or 1625 tons.

Rinman's process is carried out on the following lines. The black liquor already suitably concentrated to the required density is mixed with a small proportion of caustic soda liquor and a carefully calculated quantity of quick lime. This mixture when showing a density of about 40° Beaume is kept at a high temperature in proper storage tanks. The mixture is fed as required into a number of iron trays to the depth of about 2 cm. These trays fit into square shaped wagons, four of which are at one time pushed into the distillation furnace, which is perfectly airtight when closed up ready for the operation of distilling. The temperature of the oven is gradually increased to 200° C., the heat for this process being obtained by burning gases which are given off during the distillation process, any extra heat being obtained from a gas generator using coke. At 200° C. the excess moisture is driven off.

The temperature is raised to 300° C., and at this stage the bye-products given off are mainly crude methyl alcohol and hydrogen gas. These products are drawn off in a suitable manner.

At an increased temperature of 400° C., the bye-products obtained are acetone and light oils.

The whole operation of distilling occupies about 18 hours. The furnace is then cooled and the wagons drawn out of the apparatus, the contents of each trunk being tipped into water and causticised with lime. The lime mud, which is necessarily contaminated with the carbon left from the distillation process, is dried in a rotary furnace and ultimately burnt at a high temperature in another rotary furnace heated from the gas generator already described. By this means the lime mud is reconverted into quick lime which can be utilised over again in the process of causticising the crude carbonate of soda obtained from the distillation furnace.

If the Rinman process proves commercially practicable on a large scale as applied to esparto and bamboo, then the prospects for cheap bamboo pulp seem bright. The quantity of bye-products obtained as shown in the above table amount to nearly 10 per cent calculated on the original raw bamboo. At present the story reads like a fairy tale, but the fact remains that mills are being erected in Great Britain having all these new applications in view for the treatment of esparto and grasses and its application to bamboo is stated to be merely a matter of adaptation.

Mr. E. F. HEYERDAHL, of Christiania, said that last year he investigated the sulphate process and made trials with different materials. He had had a long experience in the treatment of coniferous woods, and he had also been to South Africa,

where a Norwegian company had a concession for the utilisation of papyrus. He carried out experiments with that papyrus, treating it by the sulphate process; and then made experiments with wattle wood and crushed wattle bark by the sulphate process. Recently he had made experiments with bamboo. The author proposed to carry out his digesting process in steps, first taking away the starchy matter and pectoses by boiling water and very diluted caustic soda. The author claimed that the action of the sodium hydroxide on the lignins did not take place before 130° C. That was right, and then most of the sodium hydroxide was already used up in dissolving the starch and the pectoses, but by the sulphate process there were two actual solvents on the lignine compounds, *i.e.*, sodium hydroxide and sodium sulphide. Sodium sulphide was a very strong resolvent for lignin, especially at high temperatures, and he believed that sulphide acted more strongly on lignin than sodium hydroxide, over 130° and 140° C. In treating bamboo, the sodium hydroxide would first dissolve the starch and the pectoses. That process would be completed at about 130° C., and then the sulphide would begin to act and would completely dissolve all the lignins in the bamboo. Another point about the sulphide was that it did not act upon the cellulose fibres, and, therefore, higher yields were always obtained when the sulphate process was used, about 5 per cent more yield on the material being obtained by using the sulphate process than by using the other process. When treating coniferous woods with sodium hydroxide, a brownish-coloured pulp was always obtained, owing to the fact that during the boiling the iron in the wood and the iron in the apparatus were dissolved by the sodium hydroxide and precipitated into the fibres. When the sulphate process was used, sodium sulphide dissolved all those iron precipitates, and a light greyish pulp was obtained instead of the brown pulp. In all his experiments he had only used bamboo chips, as he considered the crushing of the complete culms was not economical from a practical point of view; it required more power and he believed it was not good for the fibre. With regard to the yields, with the soda process, by a proportion of 19 to 20 per cent he had obtained 42 per cent of unbleached pulp, requiring from 16 to 18 per cent of bleaching powder on the pulp, and an average bleached yield of 37 to 39. With the sulphate process he obtained yields of from 43 to 45 per cent, with a consumption of bleaching powder of 12 to 14 per cent, the proportion of actual alkali ($NaOH$ Na_2S) being 18 to 20 per cent. When bamboo was cooked and made into a well-boiled pulp it was very easy to treat. The washing process was very easily carried out, as the water penetrated through the pulp very readily, and the washing time was reduced to about one-quarter of the time required on coniferous woods. Chipping the bamboo without considering the nodes was not good; there were too many nodes in the material and there would be a loss during boiling of about 5 to 6 per cent. The culms could be pressed in pressing rollers and then the pressed culms allowed to pass crushing rollers, which opened up the nodes and did not crush the internodes. The flat pressed culms with the crushed nodes could be chipped into chips of 4in. [illegible] in length. By that process a loss of only about ½ to 1 per cent of the material would be obtained, and at the same time the actual capacity of the digester could be utilised to deal with about double the amount of material that could be treated if crushed bamboo were employed.

Mr. Heyerdahl exhibited to the meeting some samples of bamboo pulps.

Mr. Hamel Smith remarked that, having always been very keen on the utilisation of bamboo for paper making, he would like the author to say what sort of gospel it would be safe to preach to the tropics in the time to come. It was very easy to be too sanguine on such points as had been outlined that afternoon, but after hearing a paper such as that which had been read, one realised the many technical difficulties which arose. Any one who had been used to sugar plantations could not help feeling that bamboos should be able to be cultivated on the same lines. One grew the cane within a certain area of the factory, taking good care to have the factory rather low down, if possible, because then the loads could be run down hill and the empty trucks up hill with greater facility. Also in regard to the question of transport, one should centralise the roadways or waterways so as to remove the finished product with greater facility. The experience on one estate, it seemed to him, might help on the other. Whether the production of paper from bamboo would ever become a private enterprise seemed a little doubtful. It was one of the queries he had often been asked, and he had never been able to give any satisfactory reply. Probably those who had been in the tropics would know that bamboo had been rather in bad odour on account of mosquitoes. The last estate he was on used to have the most beautiful bamboos surrounding it, but he believed that the medical authorities ordered them to be destroyed as they collected water after the rains, thus making a breeding place for mosquitoes. Would that sort of trouble rise in connection with large areas of cultivated bamboo for a factory? The sanitary authorities might raise the difficulty that the bamboos were inclined to encourage the presence of mosquitoes to a dangerous degree, and thus lessen the chances of final success.

Mr. Arthur Baker (Chairman of the Technical Section of the Paper Makers' Association) said the paper was the outcome of long and painstaking research in bamboo by Mr. Raitt, and showed what a great industry the paper trade was. In Canada and the United States the consumption of paper for newspapers alone was two million tons a year. Taking the question of bamboo and grasses, and considering it from the point of view of an industry which might be started in India, one had to look at the position of that country as a market. India was not a very big market for paper. He supposed that in pre-war days it used probably about 80,000 tons of paper a year, of which the Indian paper mills, some nine in number, produced about 32,000 tons. India had imported about 10 or 12 thousand tons of pulp, more than one-quarter of which had come from Germany and Austria. So that industry could not be started on any considerable scale. He agreed with the author as to treatment; he thought the sulphate process was undoubtedly the best, and that crushing was the correct method of dealing

with the raw material. If bamboo was to be a raw material for the paper-maker, it would require to be made on the spot, as the sulphate process created rather objectionable odours which would not be tolerated in all communities. He thought bamboo would obtain a foothold in India for printings, and it might be exported to Australia, China, and even South Africa. The question of the use of all new fibre materials resolved itself into a £ s. d. proposition. Unless bamboo could compete strictly with other raw materials, on a £ s. d. basis, it would never become an industry either in India or anywhere else.

Mr. ROLAND GREEN said that during the war they had used bamboo by crushing under a power hammer and boiling it in esparto boilers, where they had not more than 50lb. pressure. The conditions were not at all good; it wanted higher pressure and longer boiling. But they had found it quite satisfactory, and had had no trouble at all after the crushing had been arranged.

Mr. L. P. ANDREWS said it seemed to him that bamboo was a most extraordinarily easy material to handle, and he could not help thinking that it was going to be a great factor in the future.

Sir JOHN G. CUMMING, K.C.I.E., C.S.I., in proposing a vote of thanks to Mr. Raitt for his paper, and to Mr. Sindall for his kindness in reading it, said it had been known to him for many years that Mr. Raitt had been making researches in India regarding the possibilities of paper-making. Mr. Raitt, the Forest Research Institute, and the Department of the Government of India which controlled that Institute (of which the Chairman that afternoon had been one of the most distinguished members), deserved great credit for what had been done in that direction. His own interest in the matter was two-fold. He had been over a great part of the area both in Bengal and Burma, to which allusion had been made, wherein bamboo forests of the nature required were to be found. Secondly, he was intensely interested in any form which industrial expansion in India might take.

Mr. G. M. RYAN, F.L.S., late Indian Forest Service, in seconding the motion, enquired whether other plants and grasses had been examined for the purpose of finding out whether they were suitable for paper-making? For instance, there was one plant, a common weed really, which he thought might be utilised for pulp and which could be obtained in very large quantities in India, namely, *Calotropis*. The fibre was already of use, but with the bark combined, he thought it might be made applicable for paper. He, therefore, would like to ask Mr. Sindall whether it would not be possible to use it for the purpose of paper, as it contained a large amount of cellulose? With regard to bamboo unfortunately nearly all the areas where bamboos grew were really on poor soil and unfit for agriculture, so that he did not think private enterprise could develop the industry. Government would have to organise the areas referred to especially for paper. There was a very large demand in India for bamboo for huts, &c. Therefore, in considering the amount of bamboo which would be available for paper, a large quantity would have to be deducted for local needs. It would not do to infringe on the existing economic uses of bamboo. May years ago in a district in the Bombay Presidency there used to be an area of about 500 square miles extensively covered with bamboo forests, which had now disappeared, owing to the large demand for bamboo for dwellings of the people. He thought these forests be resuscitated and that no effort should be spared by the Government to do this. Another important thing was fuel supply. Wood was in large demand in India, and the problem was how to get it for burning in the paper factories. Recently there had been discovered a means by which waste vegetation could be converted into solid fuel by the Wells process which had been established in Egypt. Half-a-million acres of ground had been taken up there for cultivation, and the scheme was first of all to grow waste vegetation to feed the machines which would convert it into solid fuel. For the purposes of transport, and other means, those machines would be of great use in manufacturing fuel from waste products around the paper-pulp factories; and he wished to point out what a great advantage the new process would be for India as regards obtaining fuel in this way.

Mr. SINDALL, in replying to the vote of thanks, said that one or two interesting points had been raised on the general issue. He thought all were agreed that it was not a question of technical difficulty at all. The matters arising out of the actual treatment of the bamboo and the technical problems involved had been very largely settled. Nor were there any rival methods in use. As Mr. Baker had said, the whole question was one of £ s. d.—whether it was commercially possible. No private enterprise could possibly succeed unless there was a prospect of profit, and that was all the paper-maker or the pulp-agent was concerned with. With reference to the amount of bamboo available, the point raised by Mr. Ryan was an important one, because bamboo certainly had a distinct market value in the towns, and one would necessarily therefore be compelled to seek such regions in which bamboo was growing freely and where the cost involved was merely that of cutting down and collecting. It followed, therefore, that there would not be cultivation of bamboo as ordinarily understood, but a proper control of growth in areas allocated to or belonging to the mill. With respect to grasses, they were being used in large quantities by several mills. The difficulty with some of the grasses in India was that the yield was very low, and therefore it was not a commercial proposition. The question of the suitability of bamboo in paper-making had been settled long ago. He supposed the reason why private enterprise had been rather backward in the matter was because it cost £100,000 to £150,000 to put down even a small mill in an enterprise regarded as somewhat speculative.

UNIVERSITIES, RESEARCH, AND BRAIN WASTE.*

By J. C. FIELDS, Ph.D., F.R.S.

(Continued from p. 36).

IN the boy of promise, too, France sees the future man and treats him as a potential asset. He does not need to stop short in his education because his parents are poor. There are bourses awaiting him from the Commune, the Department, and the

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Government. Where his gifts justify it, he will be provided with the best education which the country can offer. In the advanced classes of certain Lycées as many as 75 per cent of the pupils hold bourses. The Government maintains schools of university grade for genius. Entrance to these schools is by competitive examination, and the number to be admitted each year is limited. Such schools are the Ecole Normale Supérieure and the Ecole Polytéchnique. In the Ecole Normale literary and scientific studies are both provided for. On the literary side the nmber admitted annually is limited to 30; on the scientific side to 22. The number of candidates for admission in science is normally about 150, all young men of exceptional ability. Of these then about 85 per cent are rejected. It is to be noted also that of those accepted, many will have made the attempt more than once. Conditions are pretty much the same in regard to the literary candidates. The students at the Ecole Normale follow the lectures at the Sorbonne. They also have special courses of their own, which are sometimes supplementary to those of the Sorbonne. They live in residence, study under direction, have a library at their disposition, and work in their own laboratories. After three years in residence, the students are again sifted by examination. The most gifted are directed toward the career of the university professoriate. The others supply a brilliant nucleus for the teaching staffs of the Lycées. Those students whose way has been paid by the Government are under obligation to take service with it for ten years, and it in turn is under obligation to furnish them with employment. Half the students at the Ecole Normale are under these conditions.

The number admitted annually to the Ecole Polytéchnique is in the neighbourhood of 200. These would normally constitute about 20 per cent of those who write on the examination for entrance. The course at this great engineering school lasts for two years, after which the student is sent on to the Ecole des Mines, the Ecole Centrale, the Ecole d'Artillerie, or some other school for a practical course. Of this school Joffre, Foch, Pétain, Nivelle, and others of the more notable French generals in the war just past are graduates. It was with a certain satisfaction that one learned that a Frenchman had been appointed General-in-Chief of the Allied Armies; for it was practically certain that he would be a graduate of the Ecole Polytéchnique. This would be a sure guarantee of his intellectual calibre, for he would be select among the select. One could rest assured, too, that on top of his course at the Ecole Polytéchnique he would have received an advanced technical training proportioned to his natural ability.

There is a strong mathematical trend to the training given in the Ecole Polytéchnique and it is quite remarkable what a number of famous mathematicians have been turned out by this school. It is hardly necessary to add that graduates of the school whose way has been paid by the Government are under obligation to take service with the Government. The Government, too, finds good use for their services, not alone as officers, but also in important civil capacities.

The candidate who fails to obtain entrance to the Ecole Normale or the Ecole Polytéchnique may have better success with the Ecole des Mines, or the Ecole Centrale, schools also with limited admission. In any case there will be nothing to prevent him hearing lectures at the Sorbonne, for attendance on the courses given there is not limited as at the other schools I have mentioned.

In England it will shortly be as in France that the boy of exceptional ability will be able to pursue his studies as far as he will, however indigent the circumstances of his parents may be. At present there is nothing to prevent him completing his course in the secondary school, for plenty of scholarships to that end are offered by the county councils. There are also more than enough scholarships in classics for entrance to the universities. In science and moderns, however, such scholarships are lacking. The funds to redress the balance here have been promised, so I am told, and it will not be long until arrangements have been made which will provide for carrying the boy of outstanding ability right through the secondary school and the university, or higher technical institution of university grade, and training him for research if his tastes incline that way.

The experience of the Naval Dockyard Schools in England furnishes an interesting commentary on the amount of brain waste there must be in classes of the community where better educational opportunities are not available. The schools here referred to are conducted for the benefit of shipwright apprentices who work in the Dockyards. The apprentices who distinguish themselves in their studies are transferred to the Engineering College at Keyham for a year, and if their showing justifies it, they are then sent on to the Royal Naval College at Greenwich for the three years' course at that Institution.

The majority of the present Constructive Staff at the Admiralty Dockyards were formerly students at the Dockyard Schools. These same schools have furnished a succession of distinguished Directors of Naval Construction at the Admiralty. Among these one might mention Sir William White, the designer of the pre-Dreadnoughts, and Sir Philip Watts, designer of the first Dreadnought; others are Sir E. Reed, and Sir N. Barnaby. Sir J. Marshall, who started as an apprentice in a Dockyard school, became, later on, Director of the Dockyard. Sir J. Biles, Professor of Naval Architecture at Glasgow, had the same start, and this was the case also with Mr. S. J. P. Thearle, formerly Chief Surveyor of Lloyd's. Others could be named who have occupied or who are at present occupying commanding positions with some of the largest private shipbuilding concerns in Great Britain.

What a pity it would have been had such precious material been lost to great Britain. What a pity it is that so much material of like character has been lost and is being lost to Great Britain and the Empire. What a pity it is, too, that in Canada no adequate effort has been made to salvage equally good material.

The indications are that Great Britain will, in the near future, realise more largely on her latent intellectual resources than she has done in the past. To compete with Germany in technically trained men, however, she will have to increase the flow of students from the secondary schools to the Universities and higher technical institu-

tions by every means at her command. Mr. Fisher's Education Bill will help greatly to that end when it comes completely into force seven years hence. Under its provisions a pupil who has reached the age of 14 years of age will have the alternative of continuing his studies on full time for two years longer or of studying part time until he reaches 18. This will bring him to within sight of entrance to the university. The indications as to who should take a university course ought to stand out fairly definitely by this time, and the scholarships referred to above, will, no doubt, make their appeal to the ambitious student.

In a recent number of *Nature* (August 15, 1918), Prof. R. A. Gregory has given some figures with regard to the relative attendance at universities in England, Scotland, Wales, and Ireland, the United States, and Germany, from which a little analysis will draw rather interesting conclusions. The number of university students per 10,000 population is approximately 14 in Germany, 10 in the United States, 5 in England, 17 in Scotland, 7 in Ireland, 6 in Wales. In giving the figure for the United States, Prof. Gregory has based it on the 72 universities on the accepted list of the Carnegie Foundation. In Canada, as a whole, the figure would be about 15, and in Ontario it would bulk somewhere in the neighbourhood of 25. Here no account has been taken of the difference in standards for entrance to the universities in different countries, or of the difference of age at which the student is prepared to enter. In Germany the average age at which the student leaves the gymnasium is between 20 and 21. In Great Britain the usual age of entrance to a university is between 17 and 18, except in the case of Oxford and Cambridge, where it is between 19 and 20. With us, the normal age of matriculation is 18, and it is about the same in the United States. Taking these facts into account, it will be seen that most of that which passes as university work in Great Britain, Canada, and the United States would be of gymnasial standard in Germany. If we would compare the number of students in the several countries, on the basis of the university standard in Germany, we would probably not be doing injustice to any of the other countries concerned by giving for every 10,000 of population the figures 14 in Germany, 3 in the United States, 3 in England, 6 in Scotland, 3 in Ireland, 2 in Wales, 5 in Canada, 8 in Ontario.

While in Paris last summer, I found that the total attendance for the year 1913-14 at universities and other educational institutions of university grade in France was in the neighbourhood of 26,000. This is at the rate of a little more than 6 per 10,000 population. It would hardly be necessary to cut this figure down as much as we did with the corresponding figures for other allied countries. In comparing the university status of France with that of Germany, too, it would only be fair to take account of the selective policy adopted by the former country with regard to the intellectually gifted.

One must not be too hasty in finding implications in the figures we have mentioned or in drawing conclusions from them. They do not imply that the intellectual status of Germany compared with that of England is as 14 to 3, nor do they give the relative positions of the two countries in regard to scientific achievement. The scientific status of a country is determined principally by the quality of the output of its foremost research workers. The status of England in science compared with that of Germany is in the aggregate, no doubt, higher than that given by the ratio 3 to 14. This would seem to indicate that among the scientists trained in England is to found a larger proportion of high grade ones than is the case with those who are trained in Germany. This may or may not imply a smaller proportionate waste of scientific material among the men of highest intellectual capacity in England than among those who are of a somewhat lower grade. It might imply that the average intellectual level of the classes in England from which the ranks of science are recruited is higher than that of the classes in Germany from which science draws her recruits. My own impression is that the average Englishman has been endowed by nature with more intelligence than the average German. There can be no doubt that the amount of brain power which is undeveloped and which goes to waste in England is something enormous. The one thing that the figures just given do tell us is that in Germany there are more young men in proportion to population who prolong the period of their studies and receive an advanced training than there are in other countries. Of these young men science secures its full share. As a consequence, a larger number of highly trained men are available for the purposes of science and industry in Germany than elsewhere. It would appear that men of such training have been spared by Germany during the war as they have not been spared by the Allies.

Two months ago, while in London, I had a conversation with Dr. E. C. Worden, chemical expert of the Bureau of Aircraft Production, Washington, D.C., who had been commissioned to report on the chemical factories in the occupied portion of Germany. He had furnished detailed reports on 62 chemical factories. The largest of these was the factory of the Bayer Company, at Leverkusen, 12 miles from Cologne. At this factory over 3,000 tons of pharmaceuticals, dyestuffs, and other chemicals were awaiting export. The plant is equipped with 3,500 telephones. At the time of Dr. Worden's visit, over 500 research chemists were at work, and to these several hundred more would be added as soon as the raw materials were available. According to Dr. Worden, Germany kept her technical forces unimpaired by the war. She placed her technical men in positions where they did not run too much risk.

An economic blockade has been divested of some of its terrors for the Germans, for the Haber process has been so improved that they can obtain an ample supply of nitrates from the air. Their agricultural needs in this connection, Dr. Worden states, will be satisfied for all time. At the Badische Anilin und Soda Fabrik, located near Ludwigshafen, above Coblenz, on the Rhine, they are in a position to extract the nitrogen from 2½ cubic miles of air daily. This company has a new research laboratory which, with its equipment, cost $750,000. In many cases where the Germans used a chemical plant for making explosives, they erected in the neighbourhood a substantial factory on a scale at least equal to

that of the plant which was being utilised for war purposes, and the factories so erected were all held in readiness to begin operations as soon as the war was over. The expectation was, of course, that these new plants would be paid for by the Allies, and no expense, therefore, was spared in their preparation. It is hardly necessary then to remark that Germany, so far as the chemical industry is concerned, is in splendid condition to resume competition with the other nations of the world.

It evidently behoves the Allies to increase not only their university attendance, but more particularly also their output of research workers. This would be advisable under any circumstances. It becomes doubly urgent in the face of a German competition backed by an ample supply of scientifically trained workers. Nowhere is it more necessary to take stock of one's scientific position than it is in Canada.

The figures already given for university attendance do not appear to place Canada in an unfavourable light as compared with countries other than Germany. Gauged by the second set of figures, however, Canada as a whole, and even Ontario, show to disadvantage in comparison with Germany. The actual diadvantage, too, is greater than that implied in the ratio of 8 to 14. For the 8 Ontario students would, on the average, be less mature than the 14 German students, and would include among them a smaller proportion who are engaged on more advanced work, and preparing to do research. If we limit ourselves to the upper ranges of University work, that is to say, to the preparation of research workers, Canada hardly compares with the United States, and Ontario itself is quite outclassed by certain States of the Union. It may be remarked, however, that we in Ontario are getting under way.

I have referred to the assistance in the form of scholarships and bourses extended to the poor boys in England and France. We have nothing that corresponds to this in America. Our idea of a scholarship is a comparatively small prize not at all proportionate to the keep of a boy for a year, let alone several years in succession. Our nearest approach to the English conception of a scholarship is what we call a fellowship. This, however, is only available to a graduate student. The attached stipend is usually a meagre one, and the fellowship may or may not be renewable for a second or third year. It is often utilised, too, as a pretext for securing a certain amount of cheap teaching.

(To be continued).

THE REVISION OF THE ATOMIC WEIGHT OF LANTHANUM.

Preliminary Paper—The Analysis of Lanthanum Chloride.

By GREGORY PAUL BAXTER, MUNEO TANI, and HAROLD CANNING CHAPIN.

In line with the recent determinations of the atomic weights of neodymium (Baxter and Chapin, *Journ. Am. Chem. Soc.*, 1911, xxxiii., 16; Baxter, Whitcomb, Stewart and Chapin, *ibid.*, 1916, xxxviii., 302), and praseodymium (Baxter and Stewart, *ibid.*, 1915, xxxvii., 516), the atomic weight of the closely related element, lanthanum, has been subjected to investigation by a method essentially identical with that used for the other two elements. This investigation was begun independently by Chapin, who purified by fractional crystallisation a considerable quantity of lanthanum material and began the analysis of the chloride. A second sample of impure lanthanum salt was fractionated in a similar way by Tani. Although it has not been possible to complete the analysis of a sufficient number of fractions of material to fix the atomic weight of lanthanum beyond question, yet since the work has been interrupted for an indefinite period, the preliminary results are presented in a brief fashion.

The Purification of Lanthanum Salt.

The purification of the lanthanum material was effected by fractional crystallisation of the double ammonium nitrate. The original material used by Chapin was very kindly furnished by Dr. H. C. Miner, of the Welsbach Light Company. The material fractionated by Tani consisted of the less soluble portions resulting from the fractionation of crude praseodymium ammonium nitrate (Baxter and Stewart, *loc. cit.*), which also had been furnished by Dr. Miner for the previous investigation on praseodymium.

According to Auer von Welsbach, in the crystallisation of the double ammonium nitrates, the bases separate in the order, lanthanum, cerium, praseodymium, neodymium, samarium, terbium, and ytterbium earths (A. von Welsbach, *Sitzungsb. Acad. Wiss. Wien*, 1903, cxii., 1043). Because the lanthanum separates at the head of a series of fractions the purification of lanthanum is simpler than that of any other rare earth. It is also economical of material, because rejection of fractions containing impurities is necessary at only one end of the series. The fractionation was carried out by dissolving the double nitrate in a very dilute solution of nitric acid and allowing the salt to crystallise. The crystals were then dissolved and recrystallised; the mother liquor was evaporated to crystallisation. The mother liquor of the less soluble fraction was now combined with the crystals of the more soluble and the process continued until the number of fractions was 12 or more. The mother liquor of the most soluble fraction was frequently rejected. The crystals from the least soluble fraction, as soon as it became small, were, in the case of Chapin's fractionation, separated and preserved to be united later with similar fractions, but the mixture was never returned to the fractionation series. In Tani's fractionation, as soon as the least soluble fraction became very small, it was set aside, and later added to the extreme fraction of a later series of crystals, so that no material was removed from the less soluble end of the fractionation series.

In Chapin's fractionation, 96 series of crystallisation were made, involving over 2300 fractions. In Tani's fractionation, although the number of series of crystallisations was the same, the total number of fractions was only somewhat over 1100, owing to the more frequent rejection of the most soluble fraction. The final series contained 39 fractions in Chapin's, 12 in Tani's fractionation.

The crystallisation was continued in both cases until the most soluble fraction, when its absorption spectrum was examined, seemed to be free

from praseodymium. Furthermore, the most soluble fraction in the last series of Tani's material, No. 12, was tested for cerium by passing chlorine into a suspension of its hydroxide in dilute aqueous sodium hydroxide. The cerium dioxide remaining was found to represent about 1 per cent of the whole fraction. Fraction No. 8, in the last series of crystallisations, when examined in the same way, gave no indication whatever of cerium. Since the atomic weights of cerium and lanthanum are separated by only a single unit, even 1 per cent of cerium would affect the average atomic weight of the mixture by only one-hundredth of a unit, hence the first eight fractions must have been amply pure for the purpose. The absence of cerium, since it falls between lanthanum and praseodymium in the order of separation, insures the absence of praseodymium as well.

The arc spectra of the different fractions were examined by photographing the ultra-violet region, λ5000-2200, with a Féry quartz spectrograph. Pure graphite electrodes were used. In the spectrogram of Tani's Fraction No. 11, which must have contained less than 1 per cent of cerium, the lines of this element were plainly visible, but in the case of Fractions 1 and 5, even the presence of the stronger cerium lines was doubtful. This was also the case with Chapin's fractions 3 and 4.

The Preparation of Lanthanum Chloride.—Selected fractions of material were converted to chloride in a fashion identical with that used in the case of neodymium and praseodymium, as follows. Lanthanum oxalate was precipitated with an excess of oxalic acid and the precipitate was washed, dried, and ignited in an electrically-heated muffle to a mixture of oxide and carbonate. Then the oxide was dissolved in nitric acid and the process repeated twice. The ignited oxide was now dissolved in a quartz dish in hydrochloric acid which had been distilled through a quartz condenser. After the solution had been evaporated to small bulk, the salt was separated by saturating the solution at zero degrees with hydrogen chloride conducted to the solution through a quartz tube. Centrifugal drainage followed, and then the salt was recrystallised four times in the same way. In order to remove superficial water as far as possible, it was left in a vacuum dessicator over fused potassium hydroxide for some time, with occasional crushing in an agate mortar.

All of the reagents were carefully purified by processes that have been described in some detail in the papers on atomic weights of neodymium and praseodymium.

The Drying of Lanthanum Chloride.—In order to prepare the lanthanum chloride in as nearly as possible an anhydrous condition, the crystal water was first removed by a series of processes of efflorescence, and the salt was finally fused as rapidly as possible in a current of dry hydrogen chloride. As has been pointed out previously (*Journ. Am. Chem. Soc.*, 1915, xxxvii., 527), it is of vital importance that the moisture be removed as far as possible at a low temperature before the final fusion, otherwise basic lanthanum chloride forms in appreciable quantities. The transition temperature of the heptahydrate we found to be about 91°. Therefore, until the greater part of the crystal water had been expelled, the temperature was maintained below 85°. Then the temperature was raised to about 130°, where the last molecule of crystal water evaporates. As soon as this process apparently was complete, the temperature was raised to about 360°, and kept at this point for some time. Finally, the salt was fused as rapidly as possible by means of an electrically heated sleeve. The salt was probably heated to nearly 1000° in this operation, for Bourion (Bourion, *Ann. chim. phys.*, 1910, [8] xx., 547) found the melting point to be 890°. During the drying the salt was contained in a platinum boat placed in a transparent quartz tube connected with a glass-bottling apparatus, which is essential for the subsequent handling of hygroscopic salts. (Richards and Parker, *Proc. Am. Acad.*, 1896, xxxvii., 59).

After the fusion of the lanthanum chloride it was allowed to cool rapidly, and the hydrogen chloride was displaced by nitrogen, and this in turn by air. Then the boat was transferred from the quartz tube to the weighing bottle without exposure to moisture, and weighed.

In some instances the salt gave a perfectly clear solution in water; in others, owing apparently to difficulty and delay in attaining the rather high fusing point of the chloride, traces of insoluble material were visible. Although not analysed, there is little question that this was the basic chloride, for both neodymium and praseodymium chlorides, under similar circumstances, become slightly basic (*Jour. Am. Chem. Soc.*, 1915, xxxvii., 527; 1916, xxxviii., 305). The quantity of insoluble material apparently never exceeded a few tenths of a milligrm., and on allowing the solution to stand for a day or two, the basic salt dissolved completely in most cases.

The Method of Analysis.

The method of analysis was like that previously used with neodymium and praseodymium and other chlorides. The salt was dissolved in water and the solution was diluted to a volume of 1000 to 1500 cc. in a glass-stoppered precipitating flask. Pure metallic silver, equivalent to the chloride within a few tenths of a milligrm., was weighed out, dissolved in nitric acid and diluted to about the same volume. The silver solution was then added to the chloride solution in small portions, with frequent agitation. After standing at room temperature for some time, the clear solution was tested in a nephelometer for excess of chloride or silver. The estimated deficiency of either was added in the form of 0·01 *N* solution, and the solution was again thoroughly shaken, allowed to clarify and tested as before, and the process was repeated until exactly equivalent quantities of silver and chloride had been used. In computing the quantity of silver equivalent to the chloride, allowance was made for solution removed and not returned in the nephelometric tests. In all but one of the analyses several months intervened between the precipitation and the final adjustment of equilibrium, so that occluded material had abundant opportunity to be leached out.

After the end-point of the comparison had been established, an excess of 0·05 g. of silver nitrate was added for each litre of solution and the analyses were allowed to stand some time longer. Then the silver chloride was washed several times

THE ATOMIC WEIGHT OF LANTHANUM.

Series I. $LaCl_3 : 3Ag$. Ag = 107·880. Cl = 35·457.

No. of Analysis.	Analysis.	Fraction of $LaCl_3$	Wt. of $LaCl_3$ vacuum. G.	Wt. of Ag in vacuum. G.	Wt. of Ag added or subtracted. G.	Corrected Wt. of Ag in vacuum. G.	Ratio $LaCl_3$ / 3 Ag.	Atomic Wt. of lanthanum.
1.	Chapin	C27	3·45559	4·55597	+0·00353	4·55950	0·757888	138·910
2.	Tani	C3+4	5·75303	7·59221	−0·00087	7·59134	0·757841	138·897
3.	Tani	C3+4	8·18782	10·80358	+0·00003	10·80361	0·757878	138·909
4.	Tani	T1	6·80122	8·97404	−0·00045	8·97359	0·757915	138·921
5.	Tani	T1	6·73670	8·88887	−0·00058	8·88829	0·757930	138·925
6.	Tani	T5	5·43254	7·16816	−0·00044	7·16772	0·757919	138·922
						Average,	0·757895	*138·914*

Series II. $LaCl_3 : 3AgCl$.

No. of Analysis.	Analyst.	Fraction of $LaCl_3$	Wt. of $LaCl_3$ in vacuum. G.	Wt. of AgCl in vacuum. G.	Loss in wt. on fusion. G.	Dissolved AgCl. G.	Corrected Wt. AgCl in vacuum. G.	Ratio $LaCl_3$ / 3 AgCl.	Atomic wt. of lanthanum.
7.	Chapin	C27	3·67748	6·44443	0·00014	0·00129	6·44558	0·570543	138·969
8.	Tani	C3+4	5·33464	9·35196	0·00042	0·00101a	9·35255	0·570394	138·905
9.	Tani	C3+4	5·75303	*10·08459*	*0·00029*	*0·00181*	*10·08611*	*0·570391*	*138·904*
10.	Tani	C3+4	8·18782	14·35541	0·00041	0·00125	14·35625	0·570331	138·880
11.	Tani	T1	6·80122	11·92149	0·00017	0·00200	11·92332	0·570405	138·909
12.	Tani	T1	*6·73670*	*11·80828*	*0·00021*	0·00145	*11·80952*	0·570438	138·924
13.	Tani	T5	5·43254	9·52361	0·00022	0·00124	9·52463	0·570368	138·893
							Average,	0·570410	138·912

(a) The concentration of AgCl in the aqueous washing was assumed to be the average of that found in the other experiments, 0·00120 g. per litre.

with silver nitrate solution containing 0·05 g. per litre, and many times with cold water, before being collected on a weighed platinum-sponge *Gooch crucible*. The chloride was dried in an electrically-heated air-bath at 290° for at least 18 hours and weighed. Residual moisture was determined by the loss in weight when the main bulk of the precipitate was fused in a porcelain crucible. The weight of silver chloride dissolved in 1 litre of the filtrate and silver nitrate washings, was assumed to be 0·00005 g. per litre (calculated from the solubility product of silver chloride at 20° as found by Kohlrausch, 1×10^{-10}, *Z. physik. Chem.*, 1908, lxiv., 167). Chloride dissolved in the aqueous washings, together with that obtained from the precipitating flask by rinsing with ammonia, was estimated by nephelometric comparison with standards.

In most of the experiments the portions of the original solution removed for nephelometric comparisons were rejected, and a correction of 0·00015 g. was added for each 100 cc. of solution removed. In a few experiments the test portions were returned and a correction applied for the silver chloride thus introduced.

All objects were weighed by substitution for similar counterpoises, a No. 10 Troemner balance being used for the purpose. Weights were standardised to hundredths of a milligrm. by the Richards substitution method (Richards, *Journ. Am. Chem. Soc.*, 1900, xxii., 144). The following vacuum corrections were applied.

	Specific gravity.	Vacuum correction per G.
Weights	8·3	......
$LaCl_3$	3·947a	+0·000159
AgCl	5·56	+0·000071
Ag	10·49	−0·000031

(a) Matignon, *Compt. Rend.*, 1905, cxl., 1339.

The foregoing table includes all the experiments made by Chapin and Tani. Two analyses made by W. A. Turner with another fraction are not included because the fused salt and its solution were not satisfactory in appearance.

The average atomic weight of lanthanum found by us, 138·91, is nearly one-tenth of a unit lower than the value selected by the International Committee on Atomic Weights, 139·0, but just as much higher than the value 138·8 calculated by Clarke (Smithsonian Misc. Coll., "Constants of Nature," Part V. "A Recalculation of the Atomic Weights," 1910, 403). Nearly all the earlier determinations depend upon the results of methods in which lanthanum oxide plays an important rôle. The recognised difficulty of preparing rare-earth oxides free from traces of the compounds from which they are made by ignition is probably a chief cause of the wide variation among earlier determinations.

It is to be noted that the presence of the usual companions of lanthanum, namely, cerium, praseodymium, and neodymium would raise the apparent atomic weight of lanthanum so that the value obtained in this investigation unquestionably represents a maximum.—*Journal of the American Chemical Society*, May, 1921.

ABSTRACTS OF SOME RECENT FOREIGN PATENTS.

NORWAY.—Urea being a very good fertiliser, various methods have been proposed for its production. Commercial cyanamide has been the principal material employed, it having been proposed to treat it with an acid or different acid salts. The use of acids, however, is very expensive and inconvenient. One might suppose that when commercial cyanamide or neutral or basic salts is treated with water, the cyanamide, owing to the presence of water, is converted into di-

cyanamide or ammonia. According to a recent invention by M. Egil Lie and the North-Western Cyanamide Co., of Norway, the surprising discovery has been made that urea can be obtained by employing soluble salts of alkaline or alkalino terreous metals, without the use of acids. (517900).

Humid nitrate of urea being very acid, is not satisfactory when utilised as a fertiliser, owing to the action of this acidity on the soil, and the fact that the bags in which it is packed are liable to be destroyed in damp air. All this is remedied, it is claimed, by the "Narsk Hydro-Elektrisk Kvaelstofaktieselskab" by mixing the nitrate of urea with carbonate of lime. When this fertiliser is put into a humid soil and the components of the mixture begin to act, nitrate of lime is formed, an excellent fertiliser, especially in a soil poor in lime. Free urea is also an excellent fertiliser. Then carbonic acid gas is produced, which dissolves the other plant foods, without attacking the roots. (517478).

BELGIUM.—An invention for utilisation of sewage, night-soil, &c., by M. V. D. Steyaert, consists in incorporation of bisulphate of soda, $NaHSO_4$, with the crude materials. Thus the ammoniacal matter is transformed into a solid odourless product, which can be put into bags and kept without loss of nitrogen, and is sufficiently rich in fertilising elements. A specially constructed plant is employed from which the dry fertiliser makes its exit. (517548).

HOLLAND.—A Dutch inventor, Mr. A. Messerschmitt, discovered that it is possible to decompose certain rocks containing potash, especially leucite, so rapidly and profoundly, by heating them with solutions of salts of soda at a high temperature and under pressure, that the reaction is practically utilisable to obtain potassic fertilisers soluble in water and pure potash salts. If, for example, a finely pulverised leucite slime is heated with a solution of soda salts in autoclaves under pressure, provided with agitators, the potash in the rock is displaced by soda, and a mixture is obtained formed of an aqueous solution containing the separated potassium salt and residues soluble in water, which after removal of the soda can yet give potash. The slime when dried gives a fertiliser of great value. (578368).

NOTES.

THE JOHN FRITZ MEDAL, the highest honour that can be conferred by the American engineering profession, has been presented to Sir Robert Hadfield. In presenting the medal, the American societies "express their high regard and appreciation for what the British engineers did in the war for the preservation of civilisation."

THE *Analyst* for July contains an important paper by John C. Thresh, M.D., D.Sc., F.I.C., on the "Action of Water upon Lead." A great many carefully conducted experiments are described, and as the matter is one that the late Sir William Crookes devoted much time to, on account of its great national importance, we draw attention to the following conclusions arrived at by the author: "The experiments recorded prove that water has no action whatever on lead; that it is the foreign matters dissolved in water which affect the metal, the oxygen combining with it to form a soluble oxide or hydroxide, which remains in solution (to the point of saturation) in the absence of other substances capable of combining with it. This solution is of a colloidal nature, and of such coarse degree of dispersion or so liable to adsorption that it will not pass through a Pasteur filter, and may not even pass a fine paper filter. In the presence of acids forming soluble lead salts, such salts are formed, and will pass through any filter. If the acid forms insoluble salts, these are thrown down, and may be deposited on the metal in such a way as to prevent any further action. Any soluble salts present in the water may likewise act upon the lead hydroxide. Water is merely an inert medium, by means of which these foreign substances are enabled to act upon each other, the water itself taking no part other than that of a solvent."

PROFESSIONAL STATUS.—A Fellow has directed attention to a letter which appeared in the *Sydney Morning Herald* early in February commenting on announcements regarding vacancies under the Public Service Board: Head teacher blacksmithing—qualification, technical experience in the trade, salary £371; Head teacher, plumbing—qualification, expert knowledge of the trade, salary £340; Bio-chemist, Health Department—qualification, special training in bio-chemistry, Physiological chemistry, and immunology, must hold a university degree as Bachelor of Science—salary £298 15s. Under the *nom de plume* "Perplexed Parent," the writer of the letter comments on the circumstance that a man specially trained in three abstruse branches of science is offered a salary which the authorities do not dare to offer to a plumber, and shows good reason for hesitating whether to give his son a university training or to put him to plumbing. It is clear from the above that the Australian Chemical Institute and analogous organisations in the British Commonwealth must continue to co-operate actively in fostering among Government Departments a higher appreciation of science if the Empire is to reap the best advantage from its talent.—*Journal of the Institute of Chemistry*, June, 1921.

CHILIAN STATE RAILWAY REQUIREMENTS.—Tenders are invited by the Chilean State Railways up till 10 a.m. on August 31 next for the supply of emery and grindstones, bolts, nuts, cotter-pins, rivets, nails, and screws, telegraph and telephone apparatus, chemicals, &c. The estimated value of the material required is £44,000. Copies of the specifications (In Spanish) may be seen by United Kingdom manufacturers and exporters on application at the Enquiry Room of the Department of Overseas Trade, 35, Old Queen Street, Westminster, S.W.1. It is understood that the representative of the Chilian State Railways in Paris ((88, Boulevard St. Michel) has been instructed to obtain prices in the United Kingdom and remit same by cable on the day previous to the opening of tenders.

GENERATIVE REACTIONS OF MAGNESIUM.—The demands for magnesium during the war, directed the attention of M. Matignon to the question of

new methods for manufacture of this metal. He sought for an economic method, studying the three following reactions for this object: (1) $MgCl_2\ _{sol} + C_2Ca\ _{sol} = CaO\ _{sol} + 2C_{sol} + Mg\ _{sol} + 22 \cdot 4$ cal.; (2) $MgO_{sol} + C_2Ca\ _{sol} = CaO_{sol} + 2C + Mg\ _{sol} - 8 \cdot 4$ cal.; (3) $MgOMgCl_2 + 2C_2Ca = CaOCaCl_2 + 4C + 2Mg_{sol} + 1$ cal. 1×2; in which all the bodies are refractory, except magnesium and chloride of magnesium, the latter having, however, a very high boiling point, and resisting high temperatures without rapid volatilisation. — *Comptes Rendus*, 1921.

NEW COMPANIES.

CLAPHAM DRUG STORES, LIMITED.—(175590)—Registered 7th July, 1921. 137, Landor Road, S.W.9. *To carry on the business of* Chemists and Druggists. Nominal Capital: £2,000 in 2,000 Shares of £1 each. Directors: T. C. Laws, 10, Lynette Avenue, Clapham, S.W.4.: (Governing Director). Qualification of Directors: £10. Governing Director: 250 Shares. Remuneration of Directors: *To be voted by Company in General Meeting.*

A. W. HOCKIN, LIMITED.—(175517).—Registered 2nd July, 1921. 133, Western Road, Hove, Sussex. *To acquire and carry on the* business of Chemists and Druggists. Nominal Capital: £1,500 in 1,500 Shares of £1 each. Directors: A. W. Hockin, 63, London Road, Brighton; J. Van Koert, 85, Montpelier Road, Brighton. Qualification of Directors: £100. Remuneration of Directors: To *be voted by Company in General Meeting.*

New Patents.

THIS List is specially compiled for the *Chemical News* by Messrs. Rayner & Co., Registered Patent Agents, of 5, Chancery Lane, London, W.C.2., from whom all information relating to Patents, *Trade Marks and Designs can be obtained gratuitously.*

Latest Patent Applications.

17701—Adler, R.—Manufacture of decolorizing charcoal of high activity. June 29.

17499—Carteret, G.—Preparation and purification of titanium compounds. June 27.

17661—Ellis, G. H.—Dyeing or colouring acetyl cellulose. June 29.

17833—Hormann, L.—Manufacture of acid anhydrides. June 30.

17619—Howe, B.—Production of jink oxide or blown oxides from jink ores or products. June 28.

17810—Schwargkopf, R.—Method of manufacture of raw alkali-cellulose *for working into viscose.* June 30.

Specifications published this Week.

138113—Byrness, C. P.—Process of making aldehyde, fatty acids and aldehydes from mineral oils and their distillates.

140060—Duparc, L. and Urfer, C.—Process for the synthetic *production of ammonia.*

165144—Jones, F. B., Bury E. and Minerals Separation, Ltd.—Flotation treatment of carbonaceous matter.

165167—Trotter, J. W.—Process for the production of gasoline fro[m] kerosine *and like hydrocarbon oils.*

148392—Schwabe & Co.—Process for the production of smoke o[n] the stage by means of ammonium compounds of volati[le] acids.

148885—Casale, L.—Process for preparing nitrogen or nitrogen an[d] hydrogen mixtures.

Messrs. Rayner & Co., will obtain printed copies of th[e] published specifications and will forward *on post free for the offici[al]* price of 1/- each.

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CHEMIST Wanted, with experience in analysis of Foods, etc., preference given to F.I.C. or A.I.C. Branch E. State age, experience, and salary required, to Box 840, c/o T. G. SCOTT & SON, 63, Ludgate Hill, London, E.C.4.

THE Owners of British Patent 127852 relating to a "*PROCESS FOR OBTAINING NITROGEN FROM AIR*" are desirous of entering into negotiations with firms in Great Britain to exploit the above invention either by sale of the Patent Rights, or *by granting licences to manufacture under Royalty.* Enquiries should be addressed to Messrs. ABEL & IMRAY, Chartered Patent Agents, 30, Southampton Buildings, W.C.2.

PATENTS, TRADE MARKS. Handbook and advice free—B. T. KING, British and U. S. Regd. Patent Attorney, 146a, Queen Victoria St., London. 35 years reference

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THE CHEMICAL NEWS.

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THE ASSOCIATION OF BRITISH CHEMICAL MANUFACTURERS.

THE Fifth Annual General Meeting of the Association of British Chemical Manufacturers was held at the Chemical Society's Rooms, Burlington House, Piccadilly, W.1, on Thursday, July 14, 1921, for the purpose of receiving the Reports of the Council and of the Scrutineers, and for the election of the Auditors. Sir JOHN BRUNNER, Bart., Chairman of the Association, presided.

After the notice convening the meeting had been read, the Chairman in moving the adoption of the Report, said: We have now been working as an Association for five years, and I think that to-day is a critical point in the history of the Association. We have got over the first fine flush of our enthusiasm, and we are not yet respectable by reason of old age, not settled in our policy; so that it is a critical period. Our influence, gentlemen, is great, and it is growing. Hitherto there has been no association of chemical manufacturers to which the Government, or any other body, could appeal. Now they appeal to the Association of British Chemical Manufacturers as a matter of course. There were, of course, a large number of scientific societies connected with chemistry and chemical enterprise, but this association, I believe, in the hackneyed phrase, fills a long-felt want, and I believe for that reason that we will go on and prosper. The year has been a very active one in Parliamentary work. There have been three Bills: the Dyestuffs Bill, the Safeguarding of Industries Bill, and the Railways Bill, which have all occupied the attention of your Executive. The Dyestuffs Bill has now become an Act; the other two are not yet through. The Act, of course, concerns dyestuff makers and users, and to my mind if you are going to have protective legislation, that Dyestuffs Act is the fairest way in which you can arrange such matters, because the Committee which settles questions arising under the Act is composed of both manufacturers and users. Although things have not been perfectly smooth upon that Committee, I think the difficulties are gradually being solved, the friction is being avoided, and the scheme is going to work.

With regard to the Safeguarding of Industries Bill, that is now before the House, and, as you know very well, has been closured very severely The third great piece of Parliamentary work that has been done by your Association is in connection with the Railways Bill. There has been, as you know, an Advisory Committee on this question which has met a very large number of times and reported to the Executive every month. The Railways Bill is now going through the House of Commons split up between two Committees. This Railways Bill is an extremely important thing for the whole trade of the country, and no less to chemical manufacturers. We hope to get something out of the Bill as it stands, but when the whole of the Bill is through the House and has become an Act, then will begin the real work in dealing with the details of the rates. If anybody at a Board Meeting asks the representative of his particular company on the Association what the Association is doing for the benefit of that company, there is one thing which I wish you would say straight out in answer: we are looking after the Railways Bill; that is to say; we are looking after railway rates on your behalf. If we were doing nothing else, gentlemen, that would justify the existence of the Association.

Then with regard to the other activities of the Association, we have been very busy in administrative matters, quite apart from legislative matters. The Smoke and Noxious Vapours Abatement Departmental Committee was attended on our behalf by Mr. Max Muspratt, and he gave advice, which I think is very good, to that Committee, namely, that they should work on the lines of the Alkali Act. That Act was originally I believe, very much objected to by the alkaline manufacturers, but in the long run they have found that the alkali inspectors have rather been of assistance to them in their work than otherwise. If the Committee continue their work and a Bill is in the future founded upon the same lines I think the chemical manufacturers of the country will have nothing to fear. It is the duty of all of us—and I am quite sure everybody agrees with me—to try and stop the smoke and noxious vapours nuisance. The experience of those who have lived in London during the last three months, when it has really been quite a pleasant place to live in on account of the absence of smoke, will go to show that it is the duty of the chemical manufacturers of the country to do all they possibly can to purify the atmosphere of our big towns. (Hear Hear.) Then with regard to the Home Office Regulations under the Factory and Workshops Act. The Association ought to raise the strongest protest of which it is capable against the procedure of the Home Office in this matter. As you very well know, legislation is passed now-a-days simply because the mass of it is so large that Parliament cannot attend to all the details, giving powers to Departments to make regulations which have the force of law. The Home Office actually has the power, without appeal, to prohibit any chemical process. They could to-day send an inspector to your works and say that you must not continue a certain process. I do not suppose they would venture to do such a thing as that, but they actually have the power. They have, as you know, issued certain regulations for what they term the dangerous and unhealthy parts of our business. We have been able to somewhat mitigate the effect of those draft regulations; the matter is still under negotiation, and although we shall not get any satisfaction, yet we shall not be subjected to the dangerous, so far as our businesses are concerned, parts of those regulations.

We have in the past and previous years encouraged research in many ways, and have given a substantial contribution to the Chemical Society's library.

The Joint Research Committee of the Association and of the British Chemical Plant Manufacturers' Association has been continuing its work, and I believe that it will succeed in standardising many types of plant and thus make it very much cheaper for manufacturers. It has often been a

reproach to British industry that there is so little standardisation I believe that this Research Committee will, in the course of time, very much cheapen our plant. Then further, we have to foster the production of research chemicals. We have obtained information as to what research chemicals are made in this country, and suggested to people that those which are lacking should be made by somebody. We have in these ways and in many other ways suggested to members that they should co-operate. It is, of course, a very difficult thing to get people to co-operate who are competitors in business. They have been very individualistic in the past, but there are so many ways in which they can co-operate to their mutual benefit, that this Association, I think you will agree, is doing right in endeavouring to get them to co-operate in those ways which are to their mutual advantage. (Hear Hear.) This co-operation has, as I say, taken the form of the stimulation of production of dyes and other fine chemicals, by the provision of the proper intermediates and raw materials by members of the Association. We have further co-operated by endeavouring to put the members into touch with anybody who is anxious to get certain materials and have endeavoured to find out where such materials can be acquired, and having done so we have brought together the supplier and the man requiring the particular article.

On the whole, I think you can congratulate yourselves upon having had a very successful year as an Association. We are all now going through very bad times, and my only wish for all the members of the Association is that we are now at the bottom, and that trade and industry will begin from now to rise to a pinnacle of prosperity. (Cheers.)

Dr. E. F. Armstrong, F.R.S., in seconding the motion for the adoption of the Report, said that to the majority of members of the Association the fact that the Dyestuffs Bill passed through the House, and that the Safeguarding of Industries Bill was very nearly in the same position, would be regarded as the most important events of the year. From the point of view of the chemical trade he thought they ought not to overlook two points, that whilst they had asked the Government to help to safeguard their industries during the critical period which lies ahead, they must not in any way relax their own efforts to make themselves independent of the Government. (Hear hear.) That is the first point. The second point was that this assistance from the Government would be all too dearly bought if it involved too much Government interference. (Hear hear.) His third point was the delay—so dear to the heart of the bureacrats, but the greatest enemy of trade —an if as a result of any of this new legislation they were not able to get the goods they wanted, and had to suffer those irritating delays, then it would be a great handicap. With regard to the publication of the list of research chemicals, he thought in time it would become a very valuable document, and one of which they would all be proud, and which would certainly lead to efforts being made to increase the number of those compounds valuable for research, and so emancipate them from any Continental influence. More particularly, he would like to refer to the very valuable work done in connection with chemical plant. In the old days a chemical manufacturer in this country wishing for plant had either to go to a local foundry with his own design and get it made, and then find out that it would not work, and thus be unable to profit by previous experience of others, or he had to go abroad, put himself in the hands of the Germans, and take what they chose to sell him—generally, he admitted, with satisfactory results—or he had to go to some of the few chemical plant manufacturers here and pay rather dearly for his plant, and again find that he only got to a limited extent the advantage of the experience of others. They wanted to change all that, and he thought they were beginning to change it. He was certain that the Joint Research Committee was a valuable first step in that direction.

The Treasurer, Sir Willaam Pearce, M.P., commented on the statement of accounts, and congratulated the Association on its financial position. He also referred to the present position of the Railways Bill, and stated that he would like the meeting to say if it was of fundamental importance to the industry that the Bill should go through or could they look with a certain amount of equanimity if it was held up for the time being? The House of Commons might have to make up its mind very seriously whether it would struggle to get the Bill through or whether it could be be allowed to drop and be brought up at a more convenient time. It did appear to him that if the Railways Bill were held up, at any rate, the agreement with the railway companies would have to go through, and they would then have to lose one of their great holds on the railway companies, because the payment by the State of 60 million pounds, less certain allowances, was conditional on their granting certain securities as to profits. He did not see how the financial agreement could be held up, because the position of the railway companies would be such that unless a settlement was arrived at, their debenture interest and preference dividends and many other things would be in jeopardy, because this money was owed them by the Government.

The General Manager, Mr. W. J. U. Woolcock, C.B.E., M.P., said there had been a rather serious disagreement on the question of exceptional rates. The railway companies held very strong opinions on the clauses in the Bill, and after listening to their case, he came to the conclusion that they had an almost unanswerable case; not purely from the argumentative point of view, but what was even stronger than mere argument, namely, the physical impossibility of carrying out the suggestions of the Government. The clauses as they stood would be unworkable. He thought it was physically impossible in the time allowed, to adjust the enormous number of exceptional rates, and therefore, the Government were bound to meet them on the point.

Mr. Kenneth Chance, M.A., dealt with the standardisation of chemical plant. With regard to the Railways Bill, he thought that if its passing meant a strengthening of Government control, and probably the continuation of one of the Ministries, by all means let the Bill go. They could settle things very quickly amongst themselves; the railway directors and their managers had ample opportunities of seeing the advantage of co-operation one with the other during the war,

and they knew infinitely better than the Minister of Transport how far that co-operation could usefully be carried out.

Dr. P. C. C. ISHERWOOD said that up to the time of the Dyestuffs Bill being introduced into the House of Commons they all thought that fine chemicals would be incorporated in that Bill, and he thought they would have been very much better pleased to have had fine chemicals included in that Bill than in the present Bill. The last thing that fine chemical manufacturers wanted was to adopt a check on manufacturing output. They wanted to give the freest opportunity for users in this country, particularly those who are connected with the export trade, to freely export anything which they could not, or had no prospect of manufacturing.

Mr. E. V. EVANS, O.B.E., F.I.C., thought that the one great accomplishment of the year was the passage of the Dyestuffs Bill, and he congratulated the Association upon the part which it had played in its passage through the House. The Licensing Committee, formed to work the Act, was a body of men really keen to carry out the principles laid down, the main principle being that the dye industry of this country should be fostered without prejudicing the users' interests. He would like to pay a tribute to the attitude adopted by the users' representatives on that Committee. There were many difficulties, but it would be readily imagined that the task of examining our British colours and of determining whether they are a suitable substitute to replace imported articles and then scheduling and pooling the information so that it can be used at a later stage, represented a fairly large scheme. He could assure them that the Committee was in no way satisfied that it had attained the ideal it set itself in this respect. There was already a vast amount of information collected, and it behoved them at this stage to take adequate advantage of the information that has accrued.

Mr. THOMAS MORSON thought that in view of the amount of spade work that has been done by members, the dropping of the Railways Bill would be a disaster.

The Rt. Hon. J. W. WILSON, M.P., said that the Railways Bill consisted of three parts: one to meet the question between the Government and the railways, and to avoid, by a definite Parliamentary settlement, possibly years of negotiation and law suits and legal questions which did nobody any good except the lawyers, that was the sum to be paid in satisfaction of the past war claims; secondly, to carry on some sort of agreed machinery for settling wages and salaries on the railways, which also vitally indirectly affected the public, because only by proper handling of that question could disastrous strikes be avoided on the one hand or rates cut down and the expenses of railways kept within limit. Those two he imagined the Government were sure to want to put through. The tendency had been, especially when a question arose as to dividing the Bill, that many Members of Parliament suggested that the rates question be left until another year, and of course, there was no doubt that the railways and the men would both acquiesce in that so long as they had their part of the settlement. He felt that as a body of traders they ought to make their views perfectly clear as to whether or not they would venture to defer the whole rates fixing machinery of the Bill till next year. Personally, he felt that in all big settlements of great national questions when there are three distinct interests involved, traders, railway shareholders, and men, that it was from a statesman's point of view and a general welfare point of view very much easier to get a fair settlement if they were all done at once than when one of the interests was left out. (Hear hear).

Mr. MAX MUSPRATT, J.P., felt that it was better to have a bad Railways Bill than none at the present time. It was always possible to have things improved afterwards. After all, the work that has been done it would be highly undesirable to say that in the main it should be held over. With regard to the Safeguarding of Industries Bill and the Dyestuffs Act, he agreed that ultimately the only protection was sound manufacture, and there they could do a very great deal by following up their ideas of co-operation. The Dyestuffs Act would be more or less futile if they did not believe that it was going to lead to a great deal more co-operation and delimitation. In the much more intricate problems of fine chemicals they would have to survey the ground of the whole fine chemical industry and find out what was best to be done.

Mr. THOMAS HORROCKS also spoke on the Railways Bill, and

Mr. RICHARD SELIGMAN on the Joint Research Committee work.

The CHAIRMAN replied to the points raised in the Discussion. The Report was then unanimously adopted

The following Resolution was carried:—

> "That this meeting is of the opinion that it would be unfortunate if any of the parts of the Railways Bill were dropped, and urges the Government to take every possible step to secure the passing of the Bill."

On the motion of Sir WILLIAM PEARCE, seconded by Mr. MUSPRATT, the Auditors, Messrs. Feasey & Co., were unanimously re-elected.

The report of the Scrutineers was received and adopted.

Mr. R. G. PERRY, C.B.E., proposed a hearty vote of thanks to the Chairman, which was carried with applause, and the Chairman returned thanks. The proceedings then terminated.

The Rt Hon. J. W. Wilson, M.P., has been appointed Hon. President in succession to Lord Moulton. Mr. R. G. Perry remains the Hon. Vice-President. Sir John Brunner continues in office for a second year as Chairman, and Mr. Max Muspratt succeeds Dr. E. F. Armstrong as Vice-Chairman. Sir William Pearce, M P., continues as Hon. Treasurer.

THE French Monthly Review *Arts et Métieres,* which was discontinued during the war, is again published. We have received the May number, which contains much interesting matter. The Journal is published by J. Loubart, 15, Boulevard St. Martin, Paris; price 3 francs per number.

THE office of the Australian Institute of Science and Industry has been removed to 314, Albert Street, East Melbourne.

THEORY OF MOLECULAR REFRACTIONS.

Part II.—Free and Activated Valencies.

By GERVAISE LE BAS, B.Sc.

Note on Molecular Refraction and Valency.

The following group relationships are to be noted :—

	F.	Cl.	Br.	I	Na.
	0·67	5·96	8·79	13·87	2·56
Δ		5·29	8·12	13·20	
		2×2·65	3×2·70	5×2·64	

2·65=4×0·67.

	O.	S.	Se.
	1·48	7·76	10·84
		6·28	9·36
		2×3·14	3×3·12

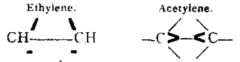
3·14=4×0·78 and 2×1·57.

It seems evident that a greater fraction of the atom affects the molecular refraction in one case than the other. (1) It is seen that there is a common factor in the different groups which is not the same for each group. (2) This seems to be related to the complexity of the elements and their genetic relations.

Free Carbon Valencies.

The molecular heats of combustion of unsaturated compounds show that the ethenoid and acetylenic linkages are weak, and that consequently a large amount of unsaturation exists. This involves the existence of free valencies. These conditions can be shown to exist by means of the molecular refractions.

Ethylene. Acetylene.

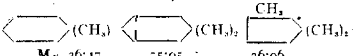


	Ethylene	Acetylene
Δ	1·56	2·12
	2×0·52	4×0·53
	+2×0·26	

The anomaly for a free valency is 0·52 The substitution of unsaturated carbon gives rise to an anomaly of 0·28 as for : C—CH_3. This substitution anomaly is lost in acetylene owing to compensation or neutralisation.

A proof that the valencies are free is found in an unique compound discovered by Zelinsky and Utskensky, and which was misnamed 3 : 3-dimethyl 0 : 1 :3-bicyclinonane.

1:1 dimethyl cyclo hexane. Zelinsky and Ulskinsky's compound.



Mx	36·47	35·95	36·96
Δ	1·57	+1·02	0·04
		2×0·51	

Molecular Volumes.

Monocyclic Molecular Volumes.

Vb.p	153·4	153·6	163·3
Δ	−16·8	−16·6	−14·6

It is thus seen that the compound in question possesses two free valencies, otherwise shown by the monocylic structure.

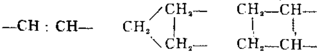
It is thus seen that free valencies can exist and are shown by the molecular refractivities. They give rise to an anomaly of 0·52.

This structure is intermediate between the ordinary 1 : 2 unsaturation and the ordinary bridged ring which may show an anomaly of 0·67 or 0·26, as in the case of some terpenes.. Part of the anomaly in the first case is due to substitution (2×0·28) Cp benzene substitution by CH_3.

Anomalies Due to Unsaturation.

Unsaturated Combinations :—

1 : 2	1 : 3	1 : 4	1 : 5

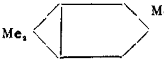


Δ	1·56	0·68	0·48	0

(Hans T. Clarke).

The unsaturation of the bridged ring thus amounts to 0·68, as follows :—

2 : 6 : 6 trimethyl 0 : 1 : 3 bicyclonane (N. M. Kishner).



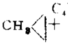
M_α 40·21 Δ+0·82

Molecular volume

Vb.p 157·6 Δ —20 { 14·5 / 5·5

1 methyl 2 isopropyl cyclopropane

$C_4H_9\beta$



M_α 37·57 Δ+0·51

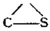
Vb.p 170·2 Δ 7·6

Zelinsky and Utskensky have thus discovered an unique compound which diverges from the bridged ring type, which is monocyclic, and possesses two free valencies.

Free Valencies in Sulphur.

The amount of activation of the supplementary valencies so far, has been shown to be 2×0·26 as for the diselenides. The Xanthates and allied compounds show many such cases. The local anomaly is, however, dependent on the general unsaturation.

It should be noted in the first place that the A. R. of doubly-bound sulphur is r_α 9·07 Δ= 9·07−7·96=1·11 (2×0·56).



or C=S<

probably the latter, since C : N shows no anomaly. Nitrogen, more difficult to activate in this way than a heavier atom, is like sulphur. Various values of sulphur are found in the Xanthates, which involve activated or free valencies.

	>S 1 7·96	> S_2 8·20	: S 9·06
		7·96	7·96
Δ		0·24	1·10
		2×0·12	2×0·55

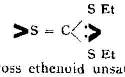
The first is a partial activation; the second is complete. Many cases exist which illustrate the rule of mutual interaction or influence resulting

in partial activation of the supplementary valencies.

	O : C(O Et)(S Et)	O : C(S Et)(S Et)
M_α	34·90	41·88
$E_{\Omega r_\alpha}$	34·74	41·12
Δ	+0·16	0·76

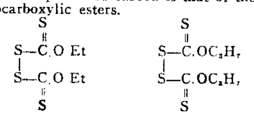
	S : C(O Et)(S Et)	S : C(S Et)(S Et)
	41·52	48·47
	42·13	50·03
	0·16	1·56 (2×0·78)

The degree of activation thus depends upon the contiguity of two sulphur atoms, and increases with the number. The influence which causes these effects is no doubt cumulative, but the activation is that of the ethereal sulphur atoms. The value 0·76 is equal to half the anomaly for an ethereal link and 1·56 the full anomaly. One might thus represent the linkage between the two contiguous sulphur atoms by



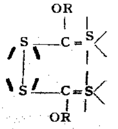
Cross ethenoid unsaturation.

Another case which shows an analogy between unsaturated sulphur and carbon is that of the dioxysulphocarboxylic esters.

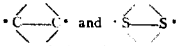


M_α	67·09		76·46
		Previous compound	67·09
C_7H_{10}	20·44	$2CH_2$	9·16
2C	4·96		
2O	3·24		76·25
2S	18·04		
2S	15·92		
	62·60		
	67·09		
	+4·49		
	4×1·12		
	8×0·56 (free valencies).		

It must be assumed that there are four pairs of free valencies in addition to the two belonging to doubly-bound sulphur. The formula would thus be :—



This remarkable case shows a sulphur atom with four activated valencies, and also a combination similar to acetylene. One thus finds

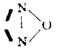


It should be stated that the great activation is possible by the continuous chain of unsaturated atoms and the requisite number of supplementary valencies.

Conclusions.—The tetravalent and hexavalent functions of sulphur are shown by the foregoing as for carbon, although part of the valencies are uncombined. Similar types of unsaturation is found in sulphur as in carbon combinations with one which is characteristic of sulphur.

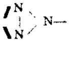
Nitrogen.

Nitrous oxide



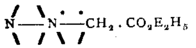
M_α	7·58	(gas)
2N	4·96	
O	1·62	
M	7·58	
$E_{\Omega r_\alpha}$	6·58	
	+1·00	(2×0·50)

The value for the triazo group N_3 is 8·96.



N^{III}	2·90	
2N	4·96	
$\Sigma_{\Omega r_\alpha}$	7·86	
M_α	8·96	
	+1·10	(2×0·55)

Curtis' compound diazo ethyl acetate is especially interesting. The anomaly is made up from 1·56+2·12=3·68, equivalent to an acetylene and ethenoid combination. The formula is :—



A complete parallelism has thus been found between carbon sulphur and nitrogen as regards the relation between unsaturation and the Molecular Refraction. Seeing that the atoms are different, there is no reason why similar numerical relations should be obtained unless the unsaturation were caused by some common circumstance not dependent upon the nature of the atom. This is unmistakable evidence for an electronic condition which is that of the unsaturated centres just stated. Electrons may be supposed to be pushed out or at least occupy positions in the absence of hydrogen which allows of retardation of the light. This side of the question is now receiving attention in England and America.

It must not be lost sight of that two overlapping conditions—the material and the electrical—exist, and it is sometimes doubtful whether the anomalies represent free valencies or not, *c.p.* anthracene and acridene. They may, however, be supposed to be free in most cases. Anomalies not connected with valencies also exist as for conjugations

—CH : CH •—• CH : CH—

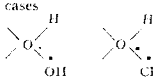
We may thus distinguish *Fundamental Anomalies* or unsaturation—that is where free valencies are

concerned. *Derived or Induced Unsaturation* for conjugations (2) and substitutions (1).

It may thus be concluded that molecular refractions are due to the light arresting or scattering power (dispersive) of valency or electronic conditions, first by the atom itself, secondly, by the free valencies [separated electrons], thirdly, by the induced electrical condition. It seems that in any electronic theory, account must be taken of the molecular refractions, and on the other hand, an adequate explanation of these must follow along the lines of an electronic theory. The writer is disposed to view the valency conditions of an atom as regional and of involving definite fractions of the atomic spaces, that is, the valency condition is such as to involve a definite fraction of the circumscribing spherical surface, and extends to the interior. Thus many electrons may be involved in the valency as a region.

It is thus to be seen that a very great extension of Eisenlohr's theory of activated supplementary valencies has been made. Only the exigencies of space have prevented the writer going into detail.

Note.—The cases



$\Delta + 1{\cdot}54$ have been referred to.

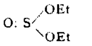
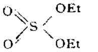
Negative Anomalies.

The cases of $(CH_3)_3C.CH_2Br$, $(CH_3)_3.C.CHBr$ have already been referred to.

Similarly thiophene and furfural have been noted (*Trans. Farad. Soc.*). Pyrrol does not show a negative anomaly, a fact which seems to be due to the presence of a positive hydrogen. For a similar reason the CH_3 group shows little disturbance.

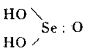
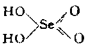
Sulphur.

It has been found that oxygen is especially liable to show a negative anomaly which frequently practically gets rid of the atomic refraction.

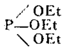
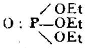
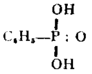
	M_α	Σnr_α	Δ
	31·62	33·60	−1·98
	31·79	35·7	−3·92
			2 × 1·96

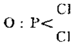
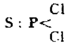
$O^{11} = 2{\cdot}12$ normally $2{\cdot}12 - 1{\cdot}98 = 0{\cdot}14$

Selenium.

	15·71		−2·61
			O_1 —0·60
			O^1_2 −2·00
	17·21	−3·21	
			: O −1·20

Phosphorus P 7·69.

	38·30	43·24	−4·94
			3 × 1·64
	41·49	45·48	—4·99
			3 × 1·66
	35·61	40·18	−4·57
			3 × 1·52

	
25·24	33·48
27·72	34·50
−2·44	−1·02

Sulphur seems less susceptible to negative anomalies than oxygen. These cases are sufficiently remarkable to form the basis of a collection of data from which cases of negative anomalies may be drawn.

The fact remains that light is not only not impeded by the passage of the light waves, but accelerated, relatively speaking. The cause of the negative anomaly is unknown, but the waves H_α pass as if the O atoms did not exist. It would be interesting to ascertain what would be the effect if shorter and probably more penetrating waves like H_β, H_γ, were used.

ATOMIC WEIGHT OF GERMANIUM.*

By JOHN H. MÜLLER.

It is recognised that the atomic weight of germanium is not accurately known, the accepted value being entirely dependent upon the investigations of its discoverer (*J. prakt Chem.*, 1886, [2] xxxiv., 177. Aside from the lack of confirmation of this constant on the part of other workers, it should be noted that Winkler's determinations were made very shortly after his discovery of the element, so that the time interval between the announcement of the existence of the new element and the determination of its atomic weight could not have permitted the determination of special means of purification to which germanium compounds may now be subjected.

The purpose of this investigation was to develop a more thorough means of purification of germanium compounds, especially in connection with the elimination of tin, arsenic, and silica, with which germanium is always associated, and to use the purified product for a redetermination of this much-neglected constant.

Winkler decomposed the tetrachloride by sodium carbonate, added an excess of standardised silver solution and titrated back the excess of the latter with ammonium thiocyanate solution. Four determinations were recorded. Winkler's reasons for the use of the Volhard method are interesting, namely, that the silver chloride which he precipitated after decomposition of the tetrachloride could not be determined gravimetrically on account of occlusion of germanic acid in the precipitated silver chloride. His effort to oxidise the disulphide with nitric acid and to precipitate the equivalent of sulphuric acid as barium sulphate also met with failure for the same reason.

Thus it is not possible to determine halogen or sulphuric acid accurately in a solution con-

*From *Journal of the American Chemical Society*, May 1921.

taining germanic acid by the usual gravimetric procedure.

This behaviour on the part of aqueous solutions of germanic oxide is analogous to the occlusion of stannic acid when the corresponding tetrachloride and sulphide of tin are treated in the same manner.

The brevity of the literature of germanium at this date is doubtless due to the great rarity of the element which until 1915-16 was not known to exist in other than a few scarce minerals, argyrodite, in which it was first found, and certain canfieldite-argyrodite mixtures.

Urbain states that Winkler's original source of germanium was not really argyrodite but mixed minerals containing much less than the theoretical 70 per cent of germanium present in the pure mineral *Compt. Rend.*, 1910, cl., 1758). Hillebrand and Scherrer in their work on gallium in spelter, mention the existence of germanium in a number of blends, as shown spectroscopically by K. Burns of the U.S. Bureau of Standards (Hillebrand and Scherrer, *J. Ind. Eng. Chem.*, 1916, viii., 225).

The same element has been reported in euxenite to the extent of 0·1 per cent (Krüss, *Ber.*, 1888, xxi., 131; *ibid.*, 1887, xx., 1665), and has been reported and also denied to be present in tantalite, samarskite, fergusonite, and some other allied minerals.

The writer has examined large quantities of Swedish samarskite, euxenite, aeschinite, and gadolinite and failed to find any germanium in these with the exception of a single sample of euxenite which contained 0·03 per cent. All of these minerals were decomposed by alkali carbonate fusion, the melts converted to chlorides, and these subjected to the hydrochloric acid and chlorine distillation method for germanium.

Argyrodite is very scarce and since its discovery in Freiberg ore in 1885 has been reported in only a few localities, notably in the silver ores of Oruro, Bolivia. Hence the recent discovery of workable quantities of germanium in the zinc oxide residues of the spelter industry, is most interesting and important. Certain of these residues contain as much as 0·25 per cent of germanium dioxide (Buchanan, *J. Ind. Eng. Chem.*, 1917, ix., 661).

Through the courtesy of the New Jersey Zinc Company, a quantity of this crude zinc oxide was procured, from which nearly all the germanium compounds used in this investigation were prepared.

The oxide-to-metal ratio for the atomic weight of germanium was tried by Winkler but was abandoned as unsatisfactory. Aside from difficulty in preventing enclosure of oxide in the reduced metal, Winkler did not mention specific reasons for his failure to obtain good results. An attempt was made to redetermine this ratio using specially constructed quartz apparatus so arranged as to prevent loss of metal by volatilisation. Results were very unsatisfactory for two reasons. First, the purity of the oxide was questionable for traces of sulphur were contained in it (when prepared from the sulphide) and small amounts of chlorine (when prepared from the tetrachloride) were not eliminated. Second, the hydrogen stream carried away small quantities of metal as hydride. This was proved by washing the waste hydrogen in a solution of silver salt, when a small black deposit was slowly formed which contained silver germanide and metallic silver.

It was noted, however, that the reduction to metal proceeded to completion at 700°, *i.e.*, 200° lower than the melting-point of the metal. Every reheating in hydrogen at this temperature, however, caused further loss in weight.

The chief difficulties in determining the chlorine in the tetrachloride, or halogen in the other halides, are twofold; the occlusion of germanic acid in the precipitated halide previously mentioned, and the instability of the halide of germanium in air and the elaborate method required for the preparation and preservation of this group of salts.

The writer examined the properties of potassium fluogermanate and found that the stability and definite character of this salt strongly recommend it in what appears to be a simple and satisfactory ratio, namely, the conversion of this compound to potassium chloride in hydrogen chloride. The ratio of potassium fluogermanate to potassium chloride offers certain important advantages. The complex salt contains no water of crystallisation, and the dried product is remarkably non-hygroscopic. It is sufficiently stable and non-volatile to withstand the action of heat at 400° to 500° without loss of weight.

The fluogermanate melts at about 730° to a clear liquid, and at about 835° rapidly vaporises without change. The salt is slightly volatile in an air current below its melting point—as might be expected, but as a much lower temperature could be used for its conversion to chloride no difficulty was encountered in this direction.

The decomposition of the double fluoride in hydrochloric acid was shown by preliminary experiments to be complete at a temperature well below 400° and in the presence of water was completed at about 100°. That is to say, tests for germanium and fluorine in the residual chloride gave entirely negative results in these cases. Concerning the final product, potassium chloride, the work of Richards on the atomic weight of potassium (Richards and Staehler, *Jour. Am. Chem. Soc.*, 1907, xxix., 623), has already shown that this salt may be weighed with great accuracy. Finally, the method outlined was free from complicated manipulation, and required no transference of material after placing the original sample of fluogermanate within the weighed platinum bulb.

Preparation of Material.

Twenty-nine kg. of germanium-bearing zinc oxide was slowly sifted into conc. commercial "C.P." hydrochloric acid (sp. gr. 1·18). Solution was nearly complete, and on cooling large masses of lead chloride crystallised out, yielding in all 3 kg. The filtrate (which measured about 65 litres) was placed in 5-gallon carboys and saturated with hydrogen sulphide under pressure. The calculated excess of hydrochloric acid present was such that the precipitate contained little else than the crude sulphides of arsenic and germanium. Siphon fillers were used to remove most of the filtrate, and the sulphides were collected in large Büchner funnels upon which they were washed and sucked as dry as possible. The sulphides were then dissolved in a very slight excess of dil. ammonium hydroxide. The thio salts obtained

were strongly acidified with hydrochloric acid, and the sulphides were reprecipitated with hydrogen sulphide, after which they were washed and dried, roasted in air in quartz vessels, and digested, with frequent addition of pure nitric acid. Ignition gave a snow-white voluminous residue of crude germanium dioxide which weighed approximately 50 g.

This oxide was introduced into a large distilling bulb, together with 20 per cent hydrochloric acid, a quartz condenser was attached, and the whole system was filled with chlorine to saturation in the cold. Distillation was then carried out in a stream of chlorine and the distillate caught in a receiver containing cold water. The distillation was repeated four times. The final distillate was then saturated with hydrogen sulphide prepared from selected pure antimony trisulphide. The snow-white germanium sulphide thus obtained was treated in quartz dishes with pure freshly-distilled nitric acid, gradually brought to dryness, and ignited. Treatment with nitric acid and subsequent ignition was repeated many times. The strongly ignited residue of oxide finally obtained weighed approximately 46 g.

The oxide was then placed in freshly distilled water contained in 3-litre Erlenmeyer flasks of well-seasoned resistance glass, the mixture stirred by a current of washed air until most of the oxide had dissolved. Warming was avoided on account of possible reaction with the glass surface. 12 litres of aqueous solution and a residue of undissolved oxide were obtained. The perfectly clear supernatant liquid was removed through a syphon filter and the residual oxide, amounting to about 3·5 g., discarded.

Later examination of this residue showed that it was nearly completely soluble in water. Several mgrms. of a white insoluble powder remained, however, which required alkali-carbonate fusion for decomposition. Indistinct tests for sulphur and silica were obtained, but lack of sufficient material prevented an exact determination of its nature.

The large volume of aqueous solution was evaporated in quartz vessels enclosed in bell jars. The dishes rested upon steam-heated copper coils, and a current of washed warm air was drawn through the system to remove water vapour. The first deposit of hydrated germanic oxide (3·4 g.) was removed by filtration and set aside. Evaporation was then continued until most of the oxide had crystallised. Slightly over a litre of mother liquor was set aside, and the middle portions of hydrated oxide deposited were filtered out, washed with a little cold water, and finally strongly ignited in platinum. 37·1 g. was obtained. The fluogermanate of potassium was now prepared from this fraction of oxide.

Potassium Fluogermanate.—The purest obtainable commercial potassium nitrate was recrystallised in platinum five times with centrifugal draining, then fractionally precipitated as chloride in quartz vessels by a stream of hydrogen chloride. The chloride was reprecipitated three times by hydrogen chloride, and the resulting chloride then converted to the acid tartrate, using tartaric acid which had been recrystallised until no weighable residue remained upon ignition of a 5 g. sample. The bitartrate after three reprecipitations was centrifuged in platinum cones and finally ignited to the carbonate in a platinum dish. Cesium, rubidium, and sodium could not be detected spectroscopically in this potassium carbonate.

Hydrofluoric acid was prepared, starting with the best commercial "C.P." acid. The common impurities in this acid are silica, lead, iron, chlorine, and organic matter. Precipitation to eliminate any of these possibly present was carried out as follows. Potassium carbonate, prepared as described above, was added to the hydrofluoric acid, but no visible trace of any precipitate was found. The acid was then filtered through paper which had been thoroughly washed with a portion of the acid, and potassium fluoride was then added, the acid distilled from a platinum retort and condenser, and redistilled first in presence of a little permanganate and then over a little pure silver fluoride, formed by adding a little silver carbonate to the acid. The resulting purified acid was then again distilled alone, and tested for non-volatile matter, but gave no weighable residue.

The pure germanium dioxide described above was warmed in a platinum dish with an excess of this acid until solution took place. Very slightly more than the calculated amount of purified potassium carbonate was added to the hot, perfectly clear, acid solution of the fluoride. Precipitation of the double fluoride which began in the hot solution was made as complete as possible by chilling. The precipitate was filtered out upon platinum cones and centrifuged, washed with a little cold water, fractionated by crystallisation from hot water slightly acidified with hydrofluoric acid, recrystallised four times from hot water containing a little free acid, and finally again from water alone. Each fractionation was accompanied by thorough centrifuging of the crystals and because of the marked difference in solubility of the salt in hot and cold water, all filtrates were set aside without further concentration.

The pure white glistening crystals thus obtained were preserved in a platinum vessel over sulphuric acid in a dessicator whose inner surface was protected from the action of traces of hydrogen fluoride by a coat of Canada balsam.

Reagents.

Water.—Ordinary distilled water was redistilled from alkaline permanganate solution, then from acid permanaganate, and then alone. A block-tin condenser was employed, and the distillate was received in well-seasoned Jena glass flasks. Ground glass surfaces were avoided, the receiving flasks being provided with caps ground on the outside of their necks. Spray from the still was eliminated by use of a bead-filled splash trap. The first third portions of distillates were not used.

Small quantities of specially pure water were required from time to time, to be added to the weighing bulb wherein evaporation to dryness was effected. For this purpose water prepared as described above was again distilled from an all-platinum still and condenser, collected in a receiver of the same material, and used immediately.

Hydrogen chloride was prepared by the Hare method, using arsenic and iron-free concentrated hydrochloric and sulphuric acids. The gas was washed and dried in four sulphuric acid towers filled with beads and glass wool. The generator

connection was a ground glass joint and all other connections were sealed by fusion.

Nitrogen was required only for fusion of the potassium chloride previous to the estimation of that salt. The gas was purified by passing it through sulphuric acid, over fused potassium hydroxide sticks, finely divided hot copper, again over fused caustic potash and finally through phosphorus pentoxide. Fused glass connections were used throughout.

Air.—An air current produced by a water blast was purified by passing through a silver salt solution, alkaline permanganate solution, over caustic potash, through sulphuric acid towers, over fused caustic potash and soda lime, and finally through two towers containing phosphorus pentoxide. As in the case of the nitrogen and hydrogen chloride systems all connections were of sealed glass.

Nitric acid was prepared from a commercially obtained C.P. potassium nitrate. The acid was redistilled thrice from an all-quartz apparatus; 10 cc. of the final distillate was free from non-volatile residue, and gave a negative test for chlorine and iron.

(To be continued)

UNIVERSITIES, RESEARCH, AND BRAIN WASTE.*

By J. C. FIELDS, Ph.D., F.R.S.

(Continued from p. 48).

THE fundamental defect in the educational systems on the American continent is the failure to make adequate provision for the training of the exceptionally gifted. It is quite evident that funds must be provided for the care of the mentally defective. A proposition to help those who are backward in their studies will receive a sympathetic hearing. If, however, it were proposed that the State should spend money in establishing a school for genius after the model of one or other of those which are supported by the State in France, the cry of class privilege would be raised. If there were question of extending financial aid in their studies to one or other of two boys, the first of whom was exceptionally gifted, the second of mediocre capacity, and if the man on the street were consulted in the matter, he would more likely than not advise that the money be given to the second boy on the ground that he was already handicapped in competition with the first boy.

With France, we should learn to realise that the exceptionally gifted individual is there for the good of the community. All the ameliorations which we enjoy we owe in the last resort to such individuals. The State, then, may well defray the cost of their training for it will ultimately profit more from the expenditure than those on whom the money is expended. One creative worker who adds an increment to the heritage handed down from generation to generation ultimately means more to the nation and the race than a hundred mediocrities trained to their capacity. No number of trained mediocrities could compensate for the loss of a Newton.

Whether America has lost one or more Newtons no on can say for certain. But that many, very many, who should have done creative work of a very high order have, because of defective educational facilities, failed to achieve their destiny, there can be no doubt. Because of this America in particular and the world in general are so much the poorer.

A generation ago, American university conditions were something appalling. In my own department, students were everywhere misled. The only way in which one could get an adequate grounding in the calculus was by going to Europe. This subject, which we have already referred to as the basis for most of the higher mathematical analysis, was practically everywhere mistaught. The result was that the potential mathematicians in America were sterilised. One of them, who after his American training, had the corrective of a European experience and now holds an honourable place among American mathematicians, told me ruefully that he would never recover from his early training. I have in mind another and younger man from whom his friends and teachers expected great things. His undergraduate training was of the kind referred to above. On top of it he completed a course in one of the best graduate schools on the continent. He has failed to make good, however. His graduate teachers attribute his failure to the false start given by his undergraduate training. I am inclined to accept this explanation, for I know the man, and I am convinced that he had the material in him to make a research worker. I have had my own experience in this connection. Fifteen years after I had received my grounding in the calculus I discovered, I am ashamed to say, in a German university, the University of Berlin, that it had been taught to me falsely, irremediably, and fundamentally falsely. A dislocation of 15 years in one's scientific life can hardly fail to leave its impress.

There are other subjects, I am informed, in which instruction in American universities was almost as bad as that in mathematics a generation ago. Conditions, however, have greatly improved in the interval. A student would be tolerably safe now in accepting the guidance in mathematics offered in any of the larger universities. The like, will, no doubt, be true of other subjects also. There is no longer the same urgency as formerly for a student to go abroad. Too much inbreeding, however, is not to be encouraged. A certain amount of circulation is healthful. A university, too, should avoid isolation. It should be in touch with other universities at home and abroad, and ought to be familiar with what is going on in the outside world.

The change in conditions in American universities, the improvement in instruction which has taken place during the last 25 to 30 years, is due primarily to the initiative and self-sacrifice of hundreds of young men who, from time to time, crossed the Atlantic in pursuit of knowledge. After years of study abroad, these men returned to America with a new outlook and new ideas. They were imbued with the spirit of research, and brought it with them into the universities where they received appointments. In the larger institutions there were developments along graduate and research lines. In universities both large and small, the research spirit reacted on the undergraduate work and vitalised it. Bringing a sleepy

*Reprinted from the *Transactions of the Royal Canadian Institute* February 1921.

old text-book routine institution into touch with research has all the effect of connecting a stagnant pool with running water. There are still some pools that would be the better for a little more flow.

The research workers just referred to organised scientific societies. At the meetings of these societies, papers, containing the results of their researches, were read and discussed. Journals were founded for the publication of these papers. The scientific status of the United States and the universities within its borders rose in the eyes of Europe.

The American universities a generation ago were practically all high schools with the exception of the John Hopkins University. They are now a combination of university and high school, and in certain of them the research side has been considerably emphasised. The John Hopkins was a pioneer in research. It was founded primarily as a research institution. An important feature in its policy was the appointment of big men to its professorships. Big men, however, were not always available. Furthermore, it was straitened financially. It did its best under the circumstances, and that meant much. Brick and mortar held a small place in its programme, and its buildings were less pretentious than those of the larger American universities in general. It established scientific journals, and within a few years of its foundation, its prestige in Europe eclipsed that of all other universities on this side of the Atlantic. Other universities supplied with more ample funds have followed the example of the John Hopkins, and have made research a conspicuous feature of their work. Most universities on this continent might take a lesson from the John Hopkins University in regard to the relative emphasis to be laid on men and buildings.

The improvement in the scientific and academic status of American universities during recent years I have attributed primarily to a number of individuals who studied in Europe and brought back with them to America the inspiration of research. To these are to be added scientific graduates of the John Hopkins University distributed among the educational institutions of the continent who had their share in leavening the academic sentiment and spreading the research idea. Those who now have charge of research work in American universities and those who are engaged in industrial research on this side of the Atlantic are, for the most part, pupils of the pioneers in research of whom we have just been speaking.

The research men on the staffs of American universities have done all that is humanly possible for them to do to give efficient instruction in science and to improve research conditions in their institutions. It is up to the university administrators to do their share. Salaries must be increased especially in the junior grades, and research men must not be overloaded with teaching. I could mention one of the largest universities on the continent whose policy it has been to pay its *professors the minimum for which it could get* them. A few years ago the head of a department in this university told me that the professors' salaries there ranged from $2,000 to $5,000 a year. The President was housed palatially. I could point you to another famous institution, known by name to everyone in this audience, which has on its list professors who are in receipt of a yearly salary of $2,500 or $3,000. Before the war this institution paid its instructors the princely sum of $900 a year. A few weeks ago I learned that it was now anxious to pay $1,800 for a newly-fledged B.A. as instructor in mathematics where it formerly expected to secure a man of Ph.D. grade for half that sum. This is one of the effects of the war. I could name a well-known university where they paid instructors $1,000 a year before the war. Promotion is none too rapid at this institution. Some years ago, so I was told, the head of one of the departments requested the President to increase the salary of one of his instructors to $1,500. The instructor in question was the strongest research man in his department. The President refused the request on the ground that he was not impressive looking. Fortunately, he did not have to wait long for a call elsewhere. *He is now professor in another* university, where he receives a salary better proportioned to his attainments. An eminent scientist, who was formerly head of a department in an important State university, told me that his two assistant professors, who happened to be married men, were so poorly paid that they had themselves to do their family washing.

That the university administration in America does not always appreciate the efforts of the research man is illustrated in the case of a certain State university which had several men on its staff who were interested in research. These men had published a number of papers in foreign scientific journals. This came to the ears of the Board of Regents. As it happened the Governor of the State was a member of the Board, and he lost no time in communicating with the offending professors and informing them that they were hired to teach and not to write. This story I have from a former professor of the university in question.

The administration of a university may not usually express itself in the same way as the State Governor just referred to, but its policy is frequently just as effective in discouraging research. The business administration of an American university when it comes to engaging instructors is apt to apply the law of supply and demand ruthlessly. It takes no account of the motives or ideals of those who are seeking positions on the teaching staff. Among the candidates may be one whose dearest desire in life is to find the opportunity to do research. This privilege he would not forego for anything which fortune or favour could offer him. He has already made his first contributions to knowledge, and there is every reason to believe that Nature has endowed him with gifts of the highest order. The findings of research appear to him to be the most permanent contribution to our civilisation. The great pathfinders in science he regards as the highest product of the race. By identifying himself with science through research it seems to him that he associates himself more closely with the eternal than he can *do in any other way. The only opportunity to do* research would appear to lie in a university career. The administration offers him a beggarly pittance barely sufficient to hold soul and body together. This he accepts in the expectation that he will find the time for research. Vain delusion!

He is loaded down wth lectures and tutorial work on the general business principle that the more hours his employers squeeze out of him, the more they are getting for their money. This is the kind of policy which kills the goose that lays the golden egg. The years pass. Possibly our research man gets married. He has no margin to come and go on. Promotion comes solwly. Financial worries multiply. He finds himself at last compelled to abandon his long-cherished plans for research. He broods over the futility of his sacrifices, and eats his very heart out.

Some there are who are more fortunate, who find it possible to reserve a little time for research and who manage to produce, though under handicap. A few, too, there are who, after years of struggle, arrive in a position where they are masters of the major part of their time, and can devote themselves to research, if in the intervening years their productive ardour has not abated.

If, then, scientific productivity in the American univesities to-day is greater than it was a quarter-of-a-century ago, the credit therefore is due not to the university administrations, but, as we have already stated, to members of the academic staffs, which members are also responsible for the increased efficiency of scientific instruction in the universities. For the more advanced instruction these men often receive no remuneration. They are permitted as a privilege to undertake this work in addition to their regular work. There is no eight-hour day for the research worker. For overtime he does not receive time-and-a-half pay. He gives the extra time gratis. The layman may think that the scientist is paid for the articles he publishes in the technical journals. This, however, is not the case. He does this work gratis also. The editorial work on the scientific journals is, in general, done without remuneration I may add, furthermore, that there is no money in the publication of a scientific treatise or a more advanced text-book.

The man on the street will say anyone who does so much work gratis is not practical. There is this side of it, however, that when a man has toiled a lifetime to make a fortune, the very best that he can do with it is to endow research. His benefaction to the race is then of the same effect as that of the research worker. The man of wealth contributes indirectly to the welfare of mankind. He first acquires his wealth and then uses it to subsidise the research worker. The latter makes his contribution directly. Why should we say he is less practical than the business man who has accumulated wealth? It may be that, under stress of circumstances, he consents to accept less than a decent living salary. The business administration of the university which is willing to take advantage of his position, however, can hardly be called practical for its policy is, in the long run, detrimental to the university, to science, and to the best interests of the nation.

In European universities the position of research is less incidental than in the general run of American Universities. In Germany the university is essentially a research institution, and every member of the teaching staff, as we have already indicated, is appointed on a basis of research qualifications. Practically the same result is secured in France in another way. The professoriate there is recruited from the most select of the select material which is admitted to the schools for genius, to which I have already made reference. In certain of the English universities the professorial standard is safeguarded by a system of so-called electors. For those who are not familiar with the system I may say that when a chair becomes vacant, a number of men are named whose duty it is to select a man to fill the place. These are known as electors. They are usually men of technical knowledge. Certain of them are from the institution concerned The others are outsiders. The principal evil the system is intended to guard against is appointment by local pull. The voice of the outsiders, I am told, is usually the determining factor in making the selection. I have in mind a case where there were five electors, of whom three were from outside the institution The two local electors felt under obligation to support a colleague who was a candidate for the position. The outside electors, however, said that they must have a stronger research man, and it was decided in this sense.

(To be continued).

NOTICES OF BOOKS.

A Text Book of Inorganic Chemistry for University Students. By J. R. PARTINGTON, D.Sc., M.B.E. Pp. xiii + 1062. 1921. London: Macmillan & Co., Ltd. Price 25s. net.

This text-book is primarily intended for students who have completed an introductory course of matriculation standard, although the more elementary parts of the subject are included so as to make the book complete in itself. It is not written for any particular examination, but should meet the requirements in inorganic chemistry of students preparing for the examinations of the Intermediate and Pass B.Sc. of British universities. Brief accounts of technical processes and the elements of physical chemistry are included, with worked examples on the latter. Amongst the section on Physical Chemistry, the Atomic Theory and the Periodic Law are given special prominence.

Summaries of chapters have been added where this addition has seemed likely to be useful in affording assistance in revision, and examples on all chapters are provided, the answers being collected together at the back of the book.

The book is interspersed with 439 illustrations, thus greatly hepling the student to form mental pictures of the subject being discussed.

Chemical Technology and Analysis of Oils, Fats, and Waxes. Vol. I. Sixth Edition. By Dr. J. LEWKOWITSCH, M.A., F.I.C. Edited by by GEORGE H. WARBURTON. Pp. xviii. + 682. 1921. London: Messrs. Macmillan & Co., Ltd. Price 36s. net.

This work is published in three volumes. The first is divided into twelve chapters; Chapter I., entitled "The Classification of Oils, Fats, and Waxes—Physical and Chemical Properties of Oils, Fats, and Waxes," deals with the chemical constitution of fats and the preparation and properties of pure glycerides. Chapter II., on the "Saponification of Fats and Waxes," gives an account of the different methods of saponification employed. The "Chemical and Physical Properties of the Constituents of Fats and Waxes" are discussed in the next chapter.

Methods for the examination of oils, fats, and waxes, both physical and chemical, qualitative and quantitative, are next given, this part running into nine chapters.

No index is given at the end of this volume; this is reserved for the end of Vol. III., which will contain a complete index for the whole work.

A Dictionary of Applied Chemistry. Vol. I. (A-Calcium). By Sir Edward Thorpe, C.B., LL.D., F.R.S. 1921. Pp. x.+752. London: Longmans, Green & Co. Price 60s. net.

The previous edition has been thoroughly revised, and many new articles have been added, for instance, on the Natural Organic Colouring Matters, and on the Relation of Colour to Chemical Constitution.

Extensive additions have been made to subjects of technical importance, such as sulphuric acid, nitric acid, chlorine, the metallurgy of the commercially important metals, oils, fats, &c.

A list of the contributors, with the titles of their articles, is prefixed to the several volumes, also a list of the abbreviations used in the Dictionary of the titles of Journals and Books which have been used as an authority for a statement appearing, has been inserted.

Treatise on General and Industrial Inorganic Chemistry. By Dr. Ettore Molinari. Second Edition. Translated by Thomas H. Pope, B.Sc., F.I.C., A.C.G.I. Pp. xix.+876. 1920. London: J. & A. Churchill. Price 42s. net.

This second edition is a translation of the fourth Italian edition. The translation of the original text has been adhered to as faithfully as possible, prices of chemicals, &c., have been converted into English currency per kilogrm. in the case of fine chemicals, and per ton in other instances.

The author is Professor of Chemistry at the Milan Polytechnic, and this book arose out of the author's attempts to devise a general course of inorganic chemistry for the students of this college, which would enable them to grapple with the problems of industrial chemistry in a better way than had been possible formerly.

For instance, wherever possible, the author has replaced laboratory sketches for sketches of industrial apparatus collected by him from the best works on chemical technology, from patents, or directly from practice in works which he has visited.

The first sections of the work are devoted to a short historical sketch of the progress of chemistry from the earliest times, and to a general discussion of physical laws. Part II. deals with the non-metals and their compounds, also with some of the rarer metals which act like non-metals in some of their reactions.

The third portion, which deals with the metals and their compounds, is preceded by a section on the fundamental laws of electrochemistry, and by an amplification of the electrolytic theory of solutions.

The book closes with a short summary of the periodic system of the elements.

To indicate the importance of each substance as it is dealt with in its position in the book, the author has summarised its present and past importance by means of statistics, including its commercial price; in this way one can obtain a good idea of the uses to which the substance under discussion is put to.

The book contains 328 illustrations, together with two phototype plates, and also a good index which runs into 17 pages.

Vitamines, Essential Food Factors. By Benjamin Harrow, Ph.D. London: George Routledge & Sons.

In this interesting book the subject of vitamines, one of the latest advances in the science of nutrition, is treated in a popular manner. It is astonishing to learn that a subject of such vast importance has only been recognized within the last ten years. The "vitamines," that subtle something in food-stuff whose presence or absence means life or death, is so very little understood that the very terms used in connection with it are unfamiliar to the vast majority of living people. The object of the author is to make known in a more general sense, the laborious researches that have been carried on during the last few years on this important subject.

The first part of the book is devoted to a survey of the principles of nutrition *prior* to the time when vitamines were recognised; the knowledge involved in such subjects as calories, carbohydrates, amino-acids, soap, and glycerine, is discussed in a way and in language that presents no difficulty to the layman. Six chapters are devoted to the subject of vitamines proper, their effect upon plant growth, disease, and life, are fully discussed, and the concluding chapter treats with "Practical Applications," which is certainly the most important section of the book, and is one that should be studied by everyone.

The perusal of the book, which in itself is of very great interest, brings to the reader the conviction that the further unfolding and diffusion of this important science will help greatly in the struggle that has engaged the human race from its origin in the distant past with ever-increasing intensity up to the present day—the grim fight between life and death, health and disease, happiness and misery. The author in his endeavour to bring vitamines to the attention of the general reader has done well.

A very complete bibliography is included which will be of great value to those who wish to pursue the subject further, and a complete index makes reference easy.

The Paper-Makers' Directory for All Nations. 1921. London: Dean & Son, Ltd. Price 21s.

In the editorial preface, the disastrous effect of the recent addition to the postage rates is referred to, and the serious influence upon the present trade depression is pointed out. It is also announced that it is now possible to revise and publish the Austrian and German Mill sections, which is done very completely; one cannot help noticing that the announcements of manufacturers in England and Wales occupy 57 pages, while those of Germany and Austria fill 94. The book consists of three main sections, arranged alphabetically, and records full details regarding the paper, pulp, and board mills of the world. The first part deals with mills in the United Kingdom (with many useful lists of allied trades); the second with those in the Colonies and abroad; and the third gives a comprehensive register of mill pro-

ductions under some 400 trade designations, *classified according to class of goods manufactured*, country of origin, and name of firm. Attention is drawn to the index of names of advertisers that is given at the end of the book with its obvious advantages.

The Directory is very well got up, and does credit to its publishers; it is, of course, a necessity to all purchasers of paper in quantity.

CORRESPONDENCE.

[*In our issue of May 27, we published a letter from Sir Robert Robertson, who drew attention to a statement that was made by Prof. Wilsmore in his Address.* We have just received the following explanation from Prof. Wilsmore.*—EDITOR.]

CHEMISTS AT £2 0s. 6d. PER WEEK.

To the Editor of the Chemical News.

SIR,—Sir Robert Robertson has called my attention to a regrettable error in my Presidential Address to the Chemical Section of the Australasian Association for the Advancement of Science (CHEMICAL NEWS, May 6, 1921, cxxii., 209), whereby it is made to appear that the chemists who were advertised for early in 1915 at £2 0s. 6d. per week were required for work in the Research Department at Woolwich. In reality it was the Inspection Department at the Royal Arsenal, Woolwich, which was responsible for the advertisement offering this "wage" to fully-trained chemists. The advertisement in question is quoted in full in a letter from Sir William Tilden to the CHEMICAL NEWS of February 25, 1915, cxi., 108, from which it will be seen that, with the exception of the above-mentioned error, my paraphrase was substantially correct. In any case, however, it was far from my intention to impute responsibility for this advertisement to any member of the scientific staff of the Research Department at Woolwich, least of all to Sir Robert Robertson, who has done probably more than any other man to raise the status of chemists in British Government Departments; and I regret that my words should have conveyed a contrary impression. In this connection I wish to lay stress on the value of the work which was carried out during the war in the Research Department at Woolwich by Sir Robert Robertson and his staff. Although some of that work has since been released for publication, only those who were behind the scenes can appreciate fully its importance to the nation in the critical times through which we have passed. In fact, much of the success of the late Department of Explosives Supply was undoubtedly due to the guidance and advice which at all times were placed ungrudgingly at its disposal by Sir Robert Robertson and his former colleagues in the Research Department.—I am, &c.,

N. J. M. WILSMORE.

University of Western Australia,
Perth, June 20.

*The present position of Chemistry and Chemists by Prof. N. W. Wilsmore, CHEMICAL NEWS, May 6, 1921.

CHEMICAL NOTICES FROM FOREIGN SOURCES.

Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences. Vol. clxxiii., No. 1.

"Interaction of Oxalic Acid and Iodic Acid: Second part—The Influence of Different Catalysts."—By M. Georges Lemoine.

"Action of Heat on Allyl Alcohol in the Presence of Different Catalysts."—By MM. Paul Sabatier and Bonasku Kubota.

"Ammonium Molybdate."—By M. Georges Tauret.

"The Spectra of Silicon from Molten Salts and Steels appearing with Quantitative Sensitiveness."—By M. A. De Gramont.

"Superficial Tension of Monomolecular Layers."—By M. A. Marcelin.

Vol. clxxiii., No. 2.

"*Contribution to the Study of the Stability of* Nitrocellulose Powders."—By M. Fric.

"Synthesis of Tertiaryalcohols from Methylethyketone."—By MM. Pariselle and Simon.

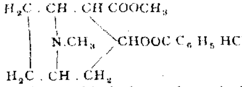
"Hydrogenation of Some Oils of Marine Animals."—By M. H. Marcelet.

"Rotatory power of Crystalline Masses."—By M Louis Longchambon.

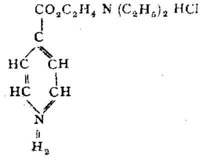
Journal de Pharmacie de Belgique, No. 27. July 3, 1921.

"Methods of Distinguishing between Cocaine Chlorhydrate, Novocaine, and Stovaine, and their Examination in Binary Mixtures."—By MM. G. Batta and C. Jenot. Owing to the fairly frequent adulteration of samples of cocaine, the above-named pharmacists of the University of Liége have given in this Journal a number of distinguishing tests.

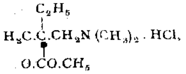
Chlorhydrate of cocaine has the following constitution:—



Novocaine is the chlorhydrate of *p*-aminobenzoyl diaminoethane.



Stovaine is the chlorhydrate of benzoylethyldi methylaminopropanol.



They have set down in a table the properties and reactions to certain chemicals of these three *anæsthetics; we have reproduced it here.*

Formula	Chlorhydrate of Novocaine $C_{13}H_{20}N_2O_2HCl$	Chlorhydrate of Cocaine $C_{17}H_{21}NO_4HCl$	Stovaine. $C_{14}H_{21}NO_2HCl$
Molecular weight	272·5	339·5	271·5
Content of hydrochloric acid	13·4	10·8	13·4
Content of nitrogen	10·2	4·1	5·2
Physical properties	Colourless needles; inodourous; *feebly bitter taste*	Anhydrous crystals; *colourless, odourless*; bitter taste	Crystalline powder; *white, odourless*; bitter taste
Solubility in water	Soluble in 1 part water	Soluble in 0·75 parts of water	Soluble in two parts of water
Solubility in alcohol	Soluble in 30 parts of alcohol	Soluble in 60° alcohol; difficultly soluble in absolute	Soluble; less so in absolute
Solubility in chloroform	Slightly soluble	Soluble	Soluble
Solubility in ether	Insoluble	Insoluble	Insoluble
Solubility in carbon bisulphide	Insoluble	Practically insoluble	Hardly soluble
Solubility in benzol	Insoluble	Insoluble	Hardly soluble
Melting point	+156°	183°	175°
Polarised light	*No action*		*No action*
Reaction to litmus	Neutral	Neutral	Acid
Action with $KNO_2+\beta$-naphthol	Scarlet red precipitate	No action	No action
Action with resorcinol	Intense red	No action	No action
Action with phenol	Orange red	No action	No action
Action with potassium permanganate	Rapid decolouration	Very slow decolouration	Slow decolouration
Action with dilute H_2SO_4	No odour of ether; no crystals	Odour of methylbenzoic ether; crystals of benzoic acid	Odour of benzoic ether; crystals of benzoic acid
Action with ammonia	Very feeble precipitate appearing after some minutes; liq. opalescent	Well formed crystals; clear liquid	Liquid becomes immediately milky
Action with caustic potash	Oily precipitate becoming crystalline	White precipitate	White oily precipitate
Action with borax	No precipitate	White precipitate	White precipitate, less soluble than the cocaine
Action with sodium phosphate	No precipitate	Thin opalescence in concentrated solutions	White milky precipitate
Action with ferricyanide	Blue precipitate	No precipitate	Precipitate after long standing
ction with HNO_3+KOH	No odour of benzoic ether	Odour of benzoic ether	Odour of benzoic ether
ction with potassium chromate	No precipitate	Precipitate only when HCl is added	Oily precipitate, before the addition of HCl
ction with gold chloride	Brown precipitate	Clear yellow precipitate	Clear yellow precipitate
ction with HgI_2+KI	Yellowish-white precipitate	Yellowish-white precipitate, collecting easily	Yellowish-white precipitate
ction with KI×I	Precipitate soluble in HCl	Precipitate collecting in concentrated solutions	Precipitate
ction with Cl and $PdCl_2$	Solution blackens with chlorine alone; no red precipitate	Red precipitate when the solution is not too dilute	Thin red colouration
ime water	The addition of small quantities of the reagent gives a white precipitate (2 per *cent solution)*	Two or three drops give a precipitate (2 per cent solution)	Two or three drops give a precipitate (2 per cent solution)
uming nitric acid	Combination of the mixture; residue of very spongy carbon	The mixture does not ignite	The mixture does not ignite.

In conclusion, the authors state that the anæsthetics can easily be identified one from the other in pure aqueous solutions by means of the reactions given above, especially the reactions given with resorcinol and nitric acid, which will easily distinguish between novocaine and the chlorhydrate of cocaine and stovaine, and the sodium phosphate reaction which will distinguish between stovaine and the others. The reaction of novocaine with resorcinol should prove useful for toxicological researches, as it is sensitive with 0·0001 grm. of this anæsthetic.

The authors have been able to reveal the presence of less than 0·5 per cent of novocaine in chlorhydrate of cocaine or in stovaine by either the β-naphthol or the resorcinol tests.

Sodium phosphate will reveal the presence of less than 10 per cent of stovaine in novocaine or in chlorhydrate of cocaine, the borax or the sulphuric acid reaction detecting less than 10 per cent of cocaine in novocaine.

Transactions of the American Electro-Chemical Society. Vol. xxxvii., 1920.

"Arc Images in Chemical Analysis." By Wm. Roy Mott. In this interesting paper the author describes a new method, rapid, delicate, semi-quantitative, and comprehensive, for the identification of the elements in simple and complex mixtures. Characteristic tests are given for 65 different elements, and it is claimed that any of these can be identified in their ores in a few minutes.

The method makes use of, and combines in one operation certain points in spectrum analysis, fire assay, micro-chemistry, and fractional distillation, and depends upon the phenomena which occur when a sample of the material to be tested is introduced into an arc struck between carbon poles.

The paper is devoted more to the results obtained than to the actual working details of the experiment, but it appears that when a sample of about 0·5 grm. of the material is placed in a depression in the positive carbon and the arc is started, various phenomena are observed, such as changes in the shape and colour of the arc itself or of the flame tip, and the emission of sparks, smoke, or odour, which are characteristic of various elements. The order of distillation of the elements, and the height at which they condense upon the upper carbon, are made use of; special attention being paid to the nature and colour of the deposits left upon the electrodes and the extent to which they are modified by the addition of simple reagents, as in ordinary blowpipe analysis.

The apparatus consists simply of a direct-current arc lamp, enclosed in a hood fitted with a pin-hole diaphragm, and a lens so arranged that an enlarged image of the arc is thrown upon a screen in a dark room.

The method can be applied directly to all ores, minerals, refractories, oxides, oxy-compounds, carbides, metals, and alloys. The delicacy of the test varies, but it is claimed that, in the cases of the uncommon, refractory, and valuable elements, which by the usual wet methods present the most difficulty, amounts in the order of 0·02 per cent can be detected with ease. In all cases a good idea can be obtained of the relative quantities present.

There is no doubt that, could the method be brought into general use, it would form a valuable supplement to present methods.

We congratulate the author upon his work, of which we should be interested to see a more detailed account than can be given in a single paper.

NOTES.

INSTITUTE OF METALS.—The following papers are expected to be submitted at the Annual Autumn Meeting of the Institute of Metals, to be held in Birmingham on September 21-23:—

"The Properties of Some Nickel-Aluminium-Copper Alloys." By Prof. A. A. Read, D.Met. (Cardiff), and R. H. Greaves, M.Sc. (Woolwich).

"The Effect of Increasing Proportions of Lead upon the Properties of Admiralty Gun-Metal." By R. T. Rolfe, F.I.C. (Bedford).

"The Casting of Brass Ingots." By R. Genders, M.B.E., B.Met. (Woolwich).

"The Density of the Zinc-Copper Alloys." By T. G. Bamford, M.Sc. (Birmingham).

"Experiments in the Working and Annealing of Copper." By F. Johnson, D.Sc. (Birmingham).

"The Effects of Progressive Cold-Drawing upon some of the Physical Properties of Low-Tin Bronze." By W. E. Alkins, M.Sc. (Manchester) and W. Cartwright (Buxton).

"The Extrusion Defect." By R. Genders, M.B.E., B.Met. (Woolwich).

"The Use of the Scleroscope on Light Specimens of Metals." By F. S. Tritton (Teddington).

"The Annealing of Rolled Zinc." By D. H. Ingall, B.Sc. (Birmingham).

"The Constitution and Age-Hardening of the Alloys of Aluminium with Magnesium and Silicon." By D. Hanson, D.Sc. (Teddington) and Miss M. L. V. Gayler, M.Sc. (Teddinton).

"Electrolytic Etching of Metals." By F. Adcock, M.B.E., B.Sc. (Sheffield).

"Electron—the High Magnesium Alloy." By S. Beckinsale, B.Sc. (London).

Papers will be presented and discussed at the morning sessions, the afternoons being devoted to visits to works, and the evenings to social events, including a reception by the Lord Mayor, and a garden party, whilst to conclude the meeting there will be a motor trip to Kenilworth, Warwick, and Stratford-on-Avon. A ballot for the election of members is now being arranged for the convenience of those persons who desire to participate in the Birmingham meeting. Full particulars can be obtained from the Secretary, Mr. G. Shaw Scott, M.Sc., 36, Victoria Street, London, S.W.1. Since the holding of the inaugural Autumn Meeting of the Institute in Birmingham in 1908, the membership has grown from 200 to over 1300. The coming meeting, marking as it does the first visit of the Institute to its old home, will afford a striking indication of the wonderful strides that have been made by the Institute of Metals since its timely foundation thirteen years ago.

Board of Trade Announcement.—In accordance with the provisions of Section 2 (6) of the Dyestuffs (Import Regulation) Act, 1920, the President of the Board of Trade has appointed the following: Mr. W. J. U. Woolcock, C.B.E., M.P. (Chairman), Mr. Percy Ashley, C.B. (Board of Trade), Sir Henry Birchenough, Bart., K.C.M.G., Mr. W. H. Dawson, Mr. George Douglas, Mr. E. V. Evans, O.B.E., F.I.C., Dr. M. O. Forster, F.R.S. (Director of the Salter Institute of Industrial Chemistry), Mr. L. B. Holliday, Dr. Herbert Levinstein, F.I.C., Prof. G. T. Morgan, F.R.S., Mr. James Morton, Mr. Max Muspratt, Mr. Thomas Taylor, Mr. Norman Thomas (Admiralty), Mr. G. S. Witham (War Office), together with another representative of dye-using interests to be appointed shortly, to be a Committee to advise the Board of Trade with respect to the efficient and economical development of the dye-making industry.

New Patents.

This List is specially compiled for the *Chemical News* by Messrs Rayner & Co., Registered Patent Agents, of 5, Chancery Lane, London, W.C.2., from whom all information relating to Patents, Trade Marks and Designs can be obtained gratuitously.

Latest Patent Applications.

18333—Air Reduction Co., Inc.—Method of producing hydrocyanic acid and cyanides. July 6.

18334—Air Reduction Co., Inc.—Method of producing hydrocyanic acid. July 6.

18092—Bitumul-Matita Soc. Anon Romana.—Manufacture and treatment of bitumen. July 4.

18553—Claessen, C.—Process for manufacture of elastic flexible masses from nitro cellulose. July 8.

18479—Lorival Manufacturing Co., Ltd.—Manufacture of condensation of phenolic bodies with aldehydic compounds. July 7.

Specifications published this Week.

142448—Ges. Fur Chemische Industrie in Basel.—*Manufacture of* substantive ortho-oxy-ayodyestuffs and their application in dyeing.

165639—Carpmael, W.—Furnaces for the manufacture of hydrochloric acid and sodium sulphate.

Abstract Published this Week.

Bitumen and Mineral Oil.—Mr. M. E. Fyleman of 103, Cannon Street, London, has obtained a Patent No. 163519 for an improved separation of bitumen or mineral oil from rock or sand impregnated therewith. The sand, etc., is treated with an aqueous solution of substances promoting the formation of froth such as alkali soaps, turkey red oil, saponin or glue, alkali salts or hydromides or dilute acids, so that the bitumen or oil separates and rises to the surface or sinks to the bottom or forms an emulsion. The oil, etc., is then separated by a washing process. Heat may be applied to render the oil or bitumen fluid or a solvent such as paraffin oil added.

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19 AUG 1921

THE CHEMICAL NEWS.

VOL. CXXIII., No. 3199.

INTERNATIONAL PHYSICO-CHEMICAL SYMBOLS.*

(AUTHORISED FOR PUBLICATION BY THE COUNCIL OF THE CHEMICAL SOCIETY).

AT the meeting of the Council of the International Association of Chemical Societies, held in Brussels in September, 1913, it was decided that the International Commission for the Unification of Physico-Chemical Symbols "Shall appoint a small Working Committee of five members, not necessarily members of the Council, to receive and consider the reports of the National Committees, and further to suggest methods for the organisation and carrying out of future work." In accordance with this decision, the President of the International Commission (the late Sir William Ramsay) nominated the following gentlemen to serve on the Working Committee, namely, Sir William Ramsay (Chairman), Dr. Friedrich Auerbach, Prof. P. A. Guye, Prof. P. J. Walden, and Prof. Alex Findlay (Secretary), and these nominations were approved by the Commission.

In accordance with the decision of the International Commission, approved by the Council (Report, 1913, p. 27), the list of symbols recommended by the Commission was sent to the different societies affiliated with the International Association of Chemical Societies, as well as to the Ausschuss für Einheiten und Formelgrössen and the International Electrotechnical Commission, and the request was made that these societies or bodies should intimate to the Secretary any criticisms or suggestions which they might have to make regarding the symbols recommended.

The criticisms and suggestions received were considered at a meeting of the Working Committee held in Paris on May 29 and 30, 1914. At this meeting, Dr. Charles Marie was also present by invitation of the Chairman.

At the outset, the following general principles were adopted:

1. The decisions of the Committee shall be restricted to symbols for quantities of chemical or physico-chemical importance.

2. In respect of symbols for quantities used, more especially in mathematics, physics, and the various branches of applied mathematics and physics, the Committee shall restrict itself to *noting* the symbols which have been recommended or adopted by the scientific bodies specially interested in these quantities. With regard to the latter, it was resolved to include in the list of symbols only those about which there is general agreement among the specially competent bodies.

3. The decisions of the Committee shall be restricted to symbols for quantities, and shall not extend to signs for the names of units.

4. The Committee considers it to be inadvisable that any attempt should be made to *compel* authors to use the symbols which the Committee recommends. Every means, however, should be taken to *encourage* the use of these symbols, which would be revised at such times and in such ways as might appear to the Commission to be advisable.

5. With regard to the symbols for quantities which are employed in different branches of pure or applied science, the Committee considers that it is not possible in every case to obtain agreement between the different sciences. It is of opinion, therefore, that the symbols suggested should be such as might find general acceptance by chemists and physico-chemists.

6. The Committee recommends that in every case authors should express their results in C.G.S. units.

On the basis of these general principles, the Committee drew up, for the approval of the International Commission, the list of symbols given below. This list of symbols was circulated among the members of the Working Committee, and was returned to me approved and initialled by Sir William Ramsay, Dr. Auerbach, Professors Guye and Walden, and Dr. Marie. It was the intention, after taking account of any remarks made by the members of the Committee, to circulate the final list for signature by the members of the Committee, but the outbreak of war prevented this from being done. These remarks have, however, been taken account of in the list given below, which may be taken as being practically identical with that initialled by the individual members of the Committee.

In accordance with a recommendation of the Working Committee, it has been thought well to append to the list of symbols the reasons for the choice of symbol made by the Committee in certain debated cases.

ALEX. FINDLAY,

Secretary to the Working Committee.

List of Symbols recommended by the Working Committee of the International Commission for the Unification of Physico-Chemical Symbols (1914).

1. *Mathematical Symbols.*

	Usual symbol.	Alternative symbol.
Base of natural (Napierian) logarithms	e	
Diameter	d	
Radius	r	
Ratio of circumference to diameter	π	
Summation	Σ	
Variation	δ	
Total differential	d	
Partial differential ...	∂	

2. *Universal Constants.*

	Usual symbol.	Alternative symbol.
Acceleration due to gravity	g	
Mechanical equivalent of heat	J	
Avogadro's constant [number of molecules in 1 gram-molecule (mole)] ...	N	
Gas constant per mole ...	R	
Faraday's constant* (number of coulombs per gram-equivalent of an ion) ...	F	
Charge on an electron ...	ϵ	

*Reprinted from the *Journal of the Chemical Society*, April, 1921.

3. *General Physics and Chemistry.*

Length	l	
Height	h	
Mass	m	
Time	t	
Volume	v, V	
Density (mass per unit volume)	d	D
Pressure	p, P	
Concentration	c, C	
Mole fraction	x	
Critical constants: pressure, volume, temperature (centigrade), temperature (absolute), density ...	p_c, v_c; t_c, T_c; d_c	
Reduced quantities: pressure, volume, temperature, density	p_r, v_r; t_r, T_r; d_r	
van der Waals's constants ...	a, b	
Fluidity	ϕ	
Viscosity	η	
Surface tension	γ	σ
Diffusion coefficient ...	Δ	
Atomic weight	A	
Molecular weight	M	
Velocity coefficient of reaction	k	
Equilibrium constant ...	$K, (K_c, K_p)$	
van't Hoff coefficient ...	i	
Degree of dissociation (electrolytic, thermal, etc.)	a	

4. *Heat and Thermodynamics.*

Temperature (centigrade) ...	t	θ
Temperature (absolute) ...	T	
Critical temperature ...	t_c, T_c	
Reduced temperature ...	t_r, T_r	
Critical solution temperature	t_{cs}, T_{cs}	
Quantity of heat	Q	
Entropy	S	
Specific heat	c	
Specific heat at constant pressure	c_p	
Specific heat at constant volume	c_v	
Ratio of specific heats, $c_p : c_v$	γ	
Molecular heat	C	
Molecular heat at constant pressure	C_p	
Molecular heat at constant volume	C_v	
Latent heat per gram ...	l	
Latent heat per mole ...	L	
Maximum work (diminution of free energy) ...	A	

5. *Optics.*

	Usual symbol.	Alternative symbol.
Wave-length of light ...	λ	
Refractive index	n	n_r
Specific refractive power (Gladstone and Dale) ...	$r_G, [r_G]^{t^\circ}_\lambda$	
Specific refractive power (Lorentz and Lorenz) ...	$r_L, [r_L]^t_\lambda$	
Molecular refractive power	R_G, R_L; $[R_G]^{t^\circ}_\lambda, [R_L]^{t^\circ}_\lambda$	
Angle of optical rotation ...	a	
Specific rotatory power ...	$[a]$	
Molecular rotatory power ...	$M[a]$	
Specific magnetic rotation ...	$[\omega]$	
Molecular magnetic rotation	$M[\omega]$	

6. *Electricity and Magnetism.*

Quantity of electricity ...	Q	
Current intensity	I	
Resistance	R	W
Electromotive force ...	E	
Electrode potential, or discharge potential of an ion	E	ε
Electrode potential referred to the normal hydrogen or normal calomel electrode respectively, the potential of which is taken as zero	E_h, E_c	$\varepsilon_h, \varepsilon$
Normal potential, *i.e.*, the electrode potential referred to the normal hydrogen or normal calomel electrode respectively, when the solution is molecular-normal in respect of all participating substances and ions of variable concentration ...	${}_0E_h, {}_0E_c$	${}_0\varepsilon_h, {}_0\varepsilon_c$
Dielectric constant ...	ε	
Conductivity (specific conductance)	κ	
Equivalent conductivity ...	Λ	
Equivalent conductivity at different dilutions—volumes in litres containing 1 gram-equivalent ...	$\Lambda_{10}, \Lambda_v, \Lambda_\infty$	
Equivalent conductivity of kation and of anion ...	Λ_k, Λ_a	
Equivalent conductivity of specified ions... ...	$\Lambda K^{\cdot}$ $\Lambda Cl'$	
Molecular conductivity ...	μ	
Velocity of kation and of anion in cm./sec. when the potential gradient is 1 volt per cm. ...	U_k, U_a	
Transport number of kation and of anion	n_k, n_a	
Magnetic permeability ...	μ	
Magnetic susceptibility ...	κ	

List of Symbols, arranged Alphabetically.

Symbol.	Name of quantity.
A	Atomic weight; maximum work
a	Van der Waals's constant
b	Van der Waals's constant
C	Concentration; molecular heat
c	Concentration; specific heat
C_p, C_v	Molecular heat at constant pressure, and at constant volume
c_p, c_v	Specific heat at constant pressure, and at constant volume
D	Alternative symbol for density
d	Diameter; total differential; density
d_c	Critical density
d_r	Reduced density
E	Electromotive force; electrode potential
e	Base of Napierian logarithms; charge on an electron
E_h, E_c	Electrode potential referred to the normal hydrogen or the normal calomel electrode, respectively, the potential of which is taken as zero
${}_0E_h, {}_0E_c$	Normal potential, that is, the electrode potential referred to the normal hydrogen or the normal calomel electrode respectively, when the solution is molecular-normal in respect of all participating substances and ions of variable concentration

F	Faraday's constant (number of coulombs per gram-equivalent of an ion)
g	Acceleration due to gravity
h	Height
I	Current
i	Van't Hoff's coefficient
Symbol.	Name of quantity.
J	Mechanical equivalent of heat
K	Equilibrium constant
K_c, K_p	Equilibrium constant, when molar concentrations and partial pressures respectively are employed
k	Velocity coefficient of reaction
L	Latent heat per mole
l	Length; latent heat per gram
M	Molecular weight
$M[\alpha]$	Molecular rotatory power
$M[\omega]$	Molecular magnetic rotatory power
m	Mass
N	Avogadro's constant (Loschmidt's number) or number of molecules in 1 gram-molecule
n	Refractive index
n_k, n_a	Transport number of kation and of anion
n_r	Refractive index (alternative symbol)
P	Pressure
p_c, p_r	Critical pressure: reduced pressure
Q	Quantity of heat; quantity of electricity
R	Gas constant per mole; electrical resistance
R_G, R_L	Molecular refractive power, according to Gladstone and Dale, and to Lorentz and Lorenz respectively
r	Radius
r_G, r_L	Specific refractive power according to Gladstone and Dale, and to Lorentz and Lorenz respectively
S	Entropy
T	Absolute temperature
T_c	Critical temperature (on the absolute scale)
T_r	Reduced temperature (absolute)
T_{cs}	Critical solution temperature (absolute)
t	Time; temperature (centigrade)
t	Critical temperature (centigrade)
t_{cs}	Critical solution temperature (centigrade)
t_r	Reduced temperature (centigrade)
U_k, U_a	Velocity of kation and of anion in cm./sec. when the potential gradient is 1 volt per cm.
V	Volume
v	Volume
v_c, v_r	Critical volume: reduced volume
W	Electrical resistance (alternative symbol)
x	Mole fraction
α	Degree of dissociation (electrolytic, thermal, etc.); angle of optical rotation
$[\alpha]$	Specific rotatory power
γ	Surface tension; ratio of specific heats
Δ	Diffusion coefficient
∂	Variable
∂	Partial differential
ϵ	Electrode potential (alternative symbol); dielectric constant
ϵ_h, ϵ	Electrode potential referred to the normal hydrogen or the normal calomel electrode respectively, the potential of which is taken as zero (alternative symbols)
$_0\epsilon_h$, $_0\epsilon_c$	Normal potential, that is, the electrode potential referred to the normal hydrogen or the normal calomel electrode respectively, when the solution is molecular-normal in respect of all participating substances and ions of variable concentration (alternative symbols
η	Viscosity
θ	Temperature (centigrade), (alternative symbol)
κ	Specific conductance (conductivity); magnetic susceptibility
Λ	Equivalent conductivity
Λ_{10}, Λ_v, Λ_∞	Equivalent conductivity at different dilutions (volumes in litres containing 1 gram-equivalent)
Λ_k, Λ_a	Equivalent conductivity of kation and of anion
λ	Wave-length of light
μ	Molecular conductivity; magnetic permeability
π	Ratio of circumference to diameter
Σ	Summation
σ	Surface tension (alternative symbol)
ϕ	Fluidity
$[\omega]$	Specific magnetic rotation

Remarks on the Symbols Recommended by the Working Committee.

Density.—The symbol ρ was suggested by the Electrotechnical Committee of Norway. The symbol d, with the alternative symbol D to be used, for example, in the differential dD/dt, was adopted, as it is the initial letter of the name of the quantity in the different European languages and is also most generally employed by chemists.

Volume.—The Committee adopted v, V as symbols for *volume* generally. The symbols v_p, v_m, &c., recommended provisionally by the International Commission in 1913 were omitted. In these and in other similar cases, the Committee considered that it was unwise to attempt to prescribe a definite symbol for every variation of the fundamental quantity. It was decided, therefore, to retain only the general symbol.

Pressure.—For reasons similar to those stated under "Volume," the Committee decided not to retain the symbol P for osmotic pressure.

Concentration.—A number of suggestions were received for symbols for concentration expressed in different units. The Committee, however, considered that it was not advisable at present to adopt special symbols for such quantities. The symbols c, C for concentration in general were therefore adopted, the author being left free to specify the units employed by him.

Critical Quantities.—The use of the Latin letters, recommended by the International Commission in 1913, was confirmed by the Committee. They were chosen in place of Greek letters, in accordance with a general principle adopted by the Commission that Greek characters should be used as sparingly as possible.

Viscosity.—The symbol η was recommended by the Internationl Commission in 1913 as being in accordance with the usage among physicists. No objections to this symbol had been received, and the Committee confirmed its adoption.

Surface Tension.—The International Commission recommended the symbol γ as chief symbol for surface tension on account of its employment in the classical researches dealing with this subject. No objections to this symbol had been received, and the Committee proposed that it should be retained, along with the alternative symbol σ,

Diffusion Coefficient.—The symbol Δ was suggested by the Spanish Chemical Society; the symbol K by the Danish Chemical Society; the symbol k by the American Chemical Society; and D by the French Chemical Society. The Committee decided to recommend the symbol Δ, which is but little used for other quantities (for example, depression of the freezing point), whereas D, K, and k are used for the important quantities, density, equilibrium constant, and velocity coefficient of reaction.

Equilibrium Constant.—The symbol K, universally employed, was retained by the Committee. The Committee adopted the suggestion, made by the Danish Chemical Society, that, where necessary or desirable, the symbols K_c and K_p be employed for the equilibrium constant when molar concentrations and partial pressures respectively are employed.

Degree of Dissociation.—The International Commission in 1913 recommended the symbol α for the degree of electrolytic dissociation in preference to the symbol γ, as the latter is employed for surface tension and for the ratio of specific heats. The Committee agreed with this, and recommended that α be adopted generally for degree of dissociation (electrolytic, thermal, &c.).

Entropy.—For this quantity, the International Commission recommended the symbol ϕ, on the grounds that this symbol was used by Willard Gibbs, and also because S had been adopted for molecular heat. Obections, however, had been made to the use of φ by the Bunsen Gesellschaft and by the Russian Physical Society, and the symbol η had been suggested by the American Chemical Society.

The Committee, after consideration, formed the opinion that although it is of importance to preserve, as far as possible, any symbol used in the classics of a science, reasons may exist for abandoning the classical symbol. In the present case, the symbol S appears to be most largely employed by writers on thermodynamics, and has been adopted by the International Electrotechnical Commission. For this reason, the Committee adopted the symbol S, which has also the advantage that it is a Latin and not a Greek character. The use of η as the symbol for viscosity is a further argument against the adoption of that letter as the symbol for entropy. The objection of the International Commission that S was used for molecular heat no longer exists, according to the recommendations of the Working Committee.

Specific and Molecular Heat.—On the representations of the Bunsen Gesellschaft and of the Société de chimie physique, the Committee decided to recommend the adoption of the classical symbols c and C for specific and molecular heat in place of the symbols s and S, which were recommended by the International Commission in 1913. The former symbols are those most frequently employed, and have been adopted also by the Ausschuss für Einheiten und Formelgrössen.

Ratio of Specific Heats.—The International Commission in 1913 recommended the symbol γ in preference to κ as being in growing use among physicists. The Working Committee confirmed this recommendation.

Latent eat.—The International Commission in 1913 recommended the generally employed symbols l and L for latent heat per grm. and per mole (grm.-molecule) respectivelly, the small and the capital letter being employed in accordance with general principles. The Danish Chemical Society suggested the symbol q for (reversible) latent heat, and considered that it is not necessary to have different symbols for latent heat per grm. and per mole. That Society also raised objection to the use of the letters l, L on the ground that they are, or may be, employed as symbols for solubility. The Working Committee, however, confirmed the recommendation of the International Commission for the following reasons: The letter l is the initial letter of the distinctive part of the name of the quantity in the different European languages, and, further the symbols for latent heat and solubility would occur very seldom in the same formula.

Maximum Work, or ***Diminution of the Free Energy of a System.***—The International Commission in 1913 recommended the symbol W for "work." Whereas the Danish Chemical Society suggested that W may be used as a symbol for "work generally," objections have been raised to the use of W in the sense of "maximum work," or diminution of the free energy. Since it is the latter quantity that is of importance in physical chemistry, the Committee was of opinion that no symbol need be recommended for "work generally," and that the symbol A should be adopted for "maximum work." This symbol has been adopted by the Ausschuss für Einheiten und Formelgrössen and by the International Electrotechnical Commission, and is used in the majority of text-books and journals. The American Chemical Society recommended the symbol ψ $(=\epsilon - t\eta)$, the symbolism employed by Willard Gibbs. The Committee regretted that it felt it to be advisable, on the principle of disturbing existing usage as little as possible, not to adopt the Greek letters employed by Gibbs.

Refractive Index.—The symbol n (with n_r as alternative) was recommended by the International Commission in 1913 as being most generally employed. The Committee confirmed this recommendation. For the specific refractive power, according to Gladstone and Dale, and to Lorentz and Lorenz respectively, the symbols r_G and r_L, or, if it is desired to indicate the temperature and wave-length of light, the symbols $[r_G]^{t^\circ}_\lambda$ and $[r_L]^{t^\circ}_\lambda$ were adopted as general symbols by the Committee. The use of λ in this general symbol in place of D, given in the list of symbols recommended by the International Commission in 1913, seems preferable as being more general, and because λ is the symbol for the wave-length of light. As a specific example, one might write $[r_G]^{18^\circ}_D$.

Molecular Rotatory Power.—The Committee was of opinion that it is more in harmony with general principles to adopt the symbol $M[\alpha]$ for molecular rotatory power, and to redefine this

$$\text{as } M[\alpha] = \frac{\text{molecular weight} \times [\alpha]}{100} = [M].$$

Magnetic Rotation.—The Committee recommended the adoption of the symbol $[\omega]$ for specific magnetic rotation, and $M[\omega]$ for molecular magnetic rotatory power, which is defined in reference to that of water as unit.

Resistance.—The Committee recommended the

adoption of the symbol R, which has been adopted also by the International Electrotechnical Commission. On the suggestion of the Bunsen Gesellschaft, the Committee adopted the letter W as an alternative symbol for use when confusion with the gas constant may arise.

Electrode Potential.—The International Commission in 1913 recommended the symbol ϵ for electrode potential. Objections have been raised to the adoption of this symbol on the grounds that in writing, the Latin e is frequently written like the Greek ϵ, and also that the use of ϵ, especially when the suffixes h and c, for example, ϵ_h, ϵ_c, are added, is more trying to read. As the electrode potential is really an electromotive force, the Working Committee was of opinion that E, the symbol for electromotive force may also be adopted as chief symbol for electrode potential, the symbol ϵ being, however, retained as an alternative symbol.

Dielectric Constant.—The Committee decided to adopt ϵ instead of κ as the symbol for this quantity, as the former had been adopted by the Ausschuss für Einheiten und Formelgrössen and by the International Electrotechnical Commission.

Equivalent Conductivity.—The adoption of the symbol Λ was confirmed. It is defined as

$$\Lambda = \frac{1000\kappa}{\text{concentration in grm.-equivalents per litre}}$$

For the equivalent conductivity of the kation, the Committee considered that it is advisable to use the letter k as suffix in place of c (that is, Λ_k in place of Λ_c), since the former letter represents a more correct transcription of the Greek, and is also largely used at present. The Committee recommended that kation should always be spelt with a k.

Molecular Conductivity.—The Committee recommended the symbol μ

$$\left(= \frac{1000\kappa}{\text{concentration in moles per litre}} \right)$$

for the molecular conductivity. This quantity was not included in the list drawn up by the International Commission in 1913. It should be noted that this symbol should not be confused with that used by W. Ostwald for the molecular conductivity measured in reciprocal Siemens units.

ALEX. FINDLAY,
Secretary to the Working Committee.

ATOMIC WEIGHT OF GERMANIUM.*

By JOHN H. MÜLLER.

(Concluded from p. 61).

The Apparatus.—For obvious reasons the conversion of potassium fluogermanate to potassium chloride had to be effected in an all-platinum vessel, illustrated in Fig. 1. With slight modifications the weighing bulb and counterpoise were identical with those used by Smith and Van Haagen in their recent determination of the atomic weights of boron and fluorine, in this laboratory.

The capacity of the long-necked platinum weighing bulb was 30 cc. The neck was 1·5 cm. wide, and the total volume of the flask about 40 cc.

* From *Journal of the American Chemical Society*, May, 1921.

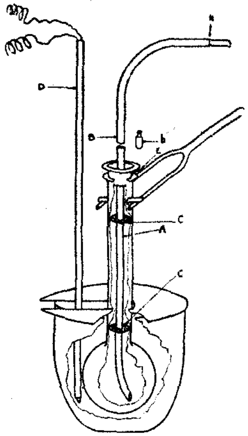

FIG. 1.

The inner tube A permitted the passage of the current of gas to the bulb and contents and was furnished with two perforated discs C. The discs were about 5 cm apart, and almost touched the walls of the neck of the flask. Their principal function was, of course, to prevent mechanical loss, but they also served to guide the inner tube into correct alignment for the adjustment of the platinum stopper, an important advantage because of the delicate nature of a ground platinum connection.

The bulb was supported upon two stout arms or lugs near the top of the flask and diametrically opposite each other. These rested upon the platinum-covered prongs of a fork projecting from a stand (not shown).

B shows the platinum elbow-tube, the end of which was ground to fit the entrance to the inner tube. A small platinum stopper ground to the same size (b) served to close the inner tube during weighing.

A large platinum crucible and perforated cover prevented direct contact of the bulb and flame; and as the temperature during each determination had to be controlled, a platinum-iridium thermocouple, D, was introduced through the crucible cover, the end of the couple being on a level with the bottom of the weighing bulb.

The waste hydrogen chloride bearing the decomposition products, germanium and tetrachloride and hydrogen fluoride, was taken off through a pure gold cap and tube G (shown in Fig. 2), and drawn through large wash-bottles containing water and caustic soda solution. The cap fitted loosely over the entire top of the flask during the

use of the hydrogen chloride but was not required while the nitrogen and air were in use. These latter gases were simply allowed to escape into the air around the stopper, which was slightly raised from its seat by means of a small piece of platinum foil inserted at E (Fig. 2). Thus the neutral gases were thrown away, but excess of acid gas was disposed of and its germanium content recovered without complicating the apparatus further by adding a side arm and stopper.

The generators and entire systems for washing and drying of air, nitrogen and hydrogen chloride were constructed wholly of glass, all connections between washing bottles being fused together, and ground connections were only used between

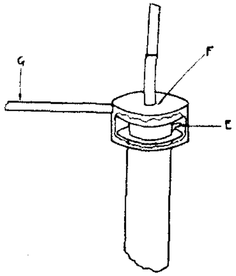

FIG. 2.

generator flasks and the anterior ends of the washing trains. These three gases passed to a three-way stopcock from which any one gas could be taken off through a single supply tube leading to the platinum connection H. The connection between glass and platinum at H was a carefully ground joint and a very tight connection was effected at this point by first grinding the glass and platinum to accurate fitting, heating the platinum and then slipping it while hot on to the cooler glass. Upon cooling and contracting, the softer platinum took fast hold and the joint remained gas-tight throughout all determinations.

The apparatus proper (excepting only the gas generators and washing systems), was enclosed in a large glass-sided cabinet furnished with a tight sliding door and a small opening at the top for the escape of hot air. This precaution was important on account of the many hours of exposure of the bulb for a single determination and served admirably to exclude dust and laboratory fumes from the vicinity of the weighing bulb.

Manipulation of the bulb and counterpoise adjustment of platinum connections, &c., were facilitated by the use of four thoroughly washed and lint-free linen finger covers. These allowed a much firmer hold of the flask and more accurate adjustment of stoppers than the usual use of tongs or handkerchief. They were kept ready for use and free from dust in a compartment of the dessicator used for the bulb and counterpoise.

Balance and Weighing.—Weighings were made were made on a Troemner balance No. 10, which is easily sensitive to 0·02 mg. The weights were carefully calibrated by Richards' substitution method. The larger weights were of gold-plated brass and the fractions of platinum. The counterpoise was a platinum flask of nearly the same weight and surface as the weighing bulb. Both bulb and counterpoise were allowed to come to the same temperature and surface condition side by side in a large dessicator, and the dessicator was allowed to remain near the balance for some hours before final weighings were taken.

For vacuum corrections, 1·995 was taken as the accepted density of potassium chloride (*Journ. Am. Chem. Soc.*, 1907, xxix., 632). The density of potassium fluogermanate had to be determined. For this purpose pure toluene distilled over sodium and redistilled alone was used. The mean of three determinations at 22° was 3·244. The corrections were of quite appreciable magnitude, amounting to +0·00045 per grm. of chloride and +0·00024 per grm. of fluogermanate.

The atomic weights used in calculating the atomic weight of germanium were chlorine, 35·46; potassium, 39·10; and fluorine, 19·00.

The Dehydration of Potassium Fluogermanate.

It is known that the removal of water from a number of double fluorides is accompanied by partial decomposition, small amounts of oxygen being introduced into the salt with the elimination of some hydrofluoric acid. As such decomposition would introduce serious error into exact determinations, the proper conditions for dehydration of the fluogermanate were studied in preliminary experiments.

A 15-g. sample of the moist centrifuged purest potassium fluogermanate was allowed to dry in dust-free air at room temperature. 4·50071 g. of this air-dried sample was then exposed to a slow current of perfectly dry air for six hours at 70° to 80°. The loss in weight was 0·00035 g. When further exposed to dry air at 450° the weight became constant after a loss of 0·00810 g. Reheating for 14 hours at the same temperature afforded no further loss. The salt then weighed 4·49128 g.

Another portion of the original air-dried salt was exposed *in vacuo* over sulphuric acid for nearly a week, when the moisture content was only slightly changed. It was then evident that the small quantity of water in the salt was enclosed within the crystals and could not be removed except at a temperature at or near the melting point. As mentioned before, the melting point of the salt is over 700°, but at that temperature it is appreciably volatile. At 450° no volatility could be detected. It seemed advisable, therefore, not to use a temperature higher than 450°; but as the long-necked flask and its perforated discs acted as a condenser, it was possible after a preliminary drying at 400° to 450° to stop the air current and raise the bottom of the flask to a higher temperature for a few moments without loss. The salt then sintered together but did not lose more weight. Accordingly the conclusion was drawn that a temperature of 450° and a slow current of air will completely dry the salt if time enough be allowed. At higher temperatures it is evident that the condensation of sublimed salt upon the obstructions well up in the neck of the flask would have introduced a greater error than the possible trace of moisture that might have been left in the salt dried at 450°.

A much higher temperature was used, of course, to melt the residual potassium chloride, but this operation was not necessary until all of the germanium and fluorine had been removed in hydrogen chloride.

Final Determinations.

The general procedure in the dehydration of the potassium fluogermanate was the same in all determinations, and may be outlined as follows.

The empty bulb, protected by the platinum crucible air-bath, was ignited at 800° for about 20 minutes, and a current of dry air was allowed to pass through the bulb during the application of heat. It was reweighed to constant weight ±0·02 mg., approximately. The sample of fluogermanate was then introduced through a platinum funnel, the stem of which projected well down into the neck of the flask. The bulb was then connected with the air supply and a slow current of dry air was passed through at 60° to 70° for three hours, then at 150° for two hours, and then the temperature was raised slowly to 400° to 450°, and so maintained for four to six hours. More than three reheatings at 400° were seldom required to give a weight constant to 0·02 or 0·03 mg.

The weighing bulb was then connected with the supply of hydrogen chloride, and this gas was allowed to act on the dry salt, at 100° to 150° for three hours, during which time the major portion of the germanium passed off. Several cubic centimetres of water was now introduced into the bulb (except in the first determination), and the aqueous mass was then carefully heated to 70° or 80° in the same gas until practically all of the water was removed. The initial partial drying took about six hours. The temperature was then elevated slowly to about 500° for a short period, and finally to the melting point of the residual chloride. The bulb was allowed to cool, water was again introduced, and the process outlined above was repeated. A third introduction of water, and repetition of the drying process was carried out in the last four determinations. The residual chloride was then raised to 600° in the presence of hydrogen chloride, and most of the latter gas was removed in a current of nitrogen at that temperature. The passage of nitrogen was continued for some time, and the chloride was finally brought to fusion. The temperature was then lowered, and the nitrogen swept out of the bulb by passing in a slow current of air for several hours. This gave the first weighing of the chloride. The entire operation described above was then repeated and carried out to obtain a constant weight of the chloride. The long time required for the complete expulsion of all of the hydrogen chloride made it advisable to prolong the first treatment with this gas far in excess of the actual time required for the conversion of the fluoride to chloride. In Determination No. 1 the operation was made entirely in the dry way. Five reheatings in hydrogen chloride were needed to arrive at constant weight within the limit of 0·04 mg. Hence the other determinations were all carried out with the use of the acid gas in the presence of water and the length of time of exposure to the acid was greatly increased to bring about the removal of the added water before high temperature was applied. It need hardly be mentioned that after the introduction of water, into the bulb, evaporation was carried to nearly complete dryness at a temperature below 100°.

One determination was lost because of the introduction of water into the bulb before the most of the germanium had been expelled in dry hydrogen chloride, the trouble being then caused by the sudden elimination of germanium along with water vapour. A deposit of germanium oxychloride was thus produced, which collected upon the upper portions of the neck of the flask and the stopper. As this part of the flask could not be properly heated and was in contact with air at all times, this determination was not carried further.

In the other six determinations, the dry fluogermanate was treated with dry hydrogen fluoride at 100° to 150° for some hours before any water was used to decompose the residual chloride and fluoride mixture. The water was added in just about sufficient quantity to dissolve the entire residue in the cold.

Results of the seven determinations are given in the table below.

Determination.	Weight of potassium fluogermanate *in vacuo*. G.	Weight of potassium chloride *in vacuo*. G.	Atomic weight of germanium K=39.10. Cl=35.46. F=19.00.
I.	1·94831	1·09814	72·37
II.	3·09380	1·74350	72·41
III.	2·10784	1·18774	72·44
IV.	2·36113	1·33044	72·44
V.	4·38070	2·46863	72·42
VI.	1·52575	0·85970	72·45
VII.	4·00100	2·25483	72·40
		Mean	72·418

Summary.

The results and conclusions derived from the preceding investigations may be summarised as follows.

1. The processes of purification of the germanium salt used for the determination of the atomic weight of this element embodied a more thorough treatment for the elimination of the known impurities of germanium than previously reported.

2. The chlorine-hydrochloric-acid distillation process, though adequate for the removal of silica and tin can hardly be accepted as a means of eliminating the last traces of arsenic from germanium compounds. Four redistillations of the chloride from hydrochloric acid solution in a stream of chlorine failed to remove the last of the arsenic.

3. The treatment of the nearly pure germanic oxide with sufficient water to dissolve nearly all of it, and the fractional crystallisation of the hydrated oxide from this solution served a two-fold purpose, to remove the much more soluble arsenic oxide at one end, and to remove any remaining traces of tin and silica in the less soluble fractions at the other. It should be noted that the formation of the potassium fluogermanate was not carried out until the absence of the isomorphous fluostannate and the silicate was insured by complete removal of tin and silica from the original oxide.

4. The stability of the final product, potassium fluogermanate, and the anhydrous nonhygroscopic nature of this salt, together with its complete decomposition in hydrochloric acid seemed to indicate that it was the most favourable compound of germanium for accurate analysis. The complete

conversion of the salt to potassium chloride was in every case established by negative tests for both germanium and fluorine.

5. The mean of seven determinations of the ratio of potassium fluogermanate to the potassium chloride equivalent gave 72·418 for the atomic weight of germanium, calculations being based on the assumption that chlorine is 35·46, fluorine, 19·00, and potassium, 39·10.

In conclusion, the above investigation suggests that an examination of other double halides of germanium and the alkalies might give desirable compounds for accurate analysis by a similar volatilisation of the germanium content, and thus furnish a check upon the results obtained in this work.

UNIVERSITIES, RESEARCH, AND BRAIN WASTE.*

By J. C. FIELDS, Ph.D., F.R.S.

(Continued from p. 63).

In America there are no recognised safeguards for the professoriate such as exist on the other side of the Atlantic. There are no traditional standards by which the candidate for a professor's chair must qualify. It is not always a question of scientific achievement. Local pull is frequently in evidence. Executive and committee work within the university and outside activities with an advertising value often receive their reward. Where, too, it is the intention of the appointing power to make the scientific status of a candidate the determining factor the scientific advice invoked is often far from competent. Some years ago the American Mathematical Society, recognising the existing state of affairs, named a committee to consider whether it might not be possible to bring the knowledge and experience of the Society to bear in the making of mathematical appointments in universities and colleges. The committee, however, reported that they were unable to devise any means for attaining the desired end.

The material which goes to make up the teaching staff of an American university is most heterogeneous. Not all the young men who enter the academic profession are of the idealistic type to which I have referred a little earlier. Their average, however, would compare favourably, I think, with the average in any other walk of life. They all look forward to professorships, of course, and one or all may ultimately arrive. Promotion in an American university is slow. The gradations leading up to a professorship are more numerous on this side of the Atlantic than in Europe. Though the scientific qualifications in America are on the whole less exacting than in Europe, advancement, for the man of ability at least, is not as rapid. The man of high attainments will find himself a professor at an earlier age in Europe than in America. However it may be in other departments of human activity, America is not the land of the young man in the field of academic work.

I have taken occasion to speak of the overloading of members of the American universities' staffs with teaching. This had reference to the professors in general as well as to the junior members of the staffs. The number of lectures which a professor in an American university is called on to give is much in excess of that demanded of his European compeer. In response to a question of mine as to the number of lectures which he was expected to give in the course of a year, a professor on the staff of Oxford told me that his position required him to lecture 28 hours in the course of the year. As a matter of fact, however, he lectured 56 hours. In France, a professor is expected to lecture three hours a week. This is usually for the academic year of 30 weeks, though some of the professors in Paris are only required to lecture 15 weeks. In Germany it is stipulated that the professor lecture at least two hours a week throughout the academic year. He, usually of his own volition, gives more than the stipulated number of hours. He is not troubled by the limitations of a fixed curriculum, it may be noted. He lectures on subjects of his own choosing, and rarely on more than two at a time.

In America it is nothing out of the ordinary for a professor to give 300 to 500 lectures in the course of a year. The layman may fancy that this is not too much, and he is likely to jump to the conclusion that the European professor has a very easy time of it. Let us see, however, how it works out. The European professor is in a position to concentrate on one subject at a time. It may be that the literature on the subject is not organised up to date. For the purpose of his course of lectures it will be necessary to organise it. To digest and collate the scattered material is likely enough to be a task of some magnitude. It will probably be as much as he can handle. It may be that it will take him several years to do the work. Here and there, by the way, he may delay over a point which needs to be cleared up or a problem whose solution would be useful. However that may be, one result of his labours will, as likely as not, be a treatise which will be of service to many more individuals than he could reach by word of mouth in the class-room. These individuals would be located in different countries and distributed over the surface of the civilised earth, including among them seasoned research workers as well as immature students. Occasionally, too, the lectures of a creative thinker will consist largely in the exposition of successive discoveries which he is making in the course of the development of a subject.

The lectures of an American university professor will rarely be of the character of the lectures to which we have just referred. They car not have such character if they are to run intc the hundreds annually. As a matter of fact many of the so-called lectures in universities or this continent consist entirely of text-book work and are purely tutorial in their character. Thi is necessarily the case in institutions which ar half high school and half university.

The typical American professor who lectures o a multiplicity of subjects simultaneously ca hardly concentrate on any one of them. He cei tainly cannot concentrate on all. He has to b perpetually changing interest as he jumps fror one subject to another. He has to be content wit placing himself in position from day to day wit regard to the successive parts of the several sul jects, and the position in which he places himsel is pretty much the same from one year to anothe

*Reprinted from the *Transactions of the Royal Canadian Institute* February 1921.

so that the same lectures are repeated from year to year and finally become a matter of routine.

The lecturer who concentrates on one subject at a time, and changes that subject from year to year or at longer intervals, covers a much larger territory in the end than the man who drives the same half-dozen subjects abreast year after year. Besides this, he has a much better command over his material. The conditions best adapted to the needs of a scientist, the conditions under which he will attain his maximum as a research worker, and prove himself most efficient as a teacher, are not always clearly apprehended by American university administrations.

The American university is administered by a Board of Regents composed wholly or almost wholly of business men. There is a President appointed by the Board and appointments to the teaching staff are made by the Board on the recommendation of the President. In general the Faculty has no representation on the Board and its sole connection with the Board is through the President. There is a good deal of dissatisfaction with this arrangement, I was told while on a visit to the United States last summer. A prominent member of the academic staff of one of the principal American universities gave expression to this feeling by stating that the teaching staff was slave to the administration. There have been some experiments in the way of modifying the organisation. Representation of the Faculty on the Board of Regents has been tried. There have also been committees of the Faculty having access to the Board, and committees composed of members of the Board and members of the Faculty. With what success these tentatives have met I do not know. There does not seem to be complete unanimity with regard to the remedy which is needed for the existing state of affairs. I may say that in European universities there is no administrative body of the nature of the Board of Regents of an American University, and there is no office which corresponds to that of the American university President. The principal of a British college or university has nothing like the powers of the university President. The Faculty has far more influence in the conduct of affairs than is the case in America. This is in evidence in the making of appointments. For example, where the system of electors is in operation the Faculty has a voice in choosing the electors. It also has its say in the case of universities where the system of electors has not been adopted.

In our Canadian universities we have the American form of administration. Our curriculum and academic standard, however, have been imported from Great Britain. We have adopted the idea of the honours courses, and these courses at the University of Toronto are probably the heaviest undergraduate courses on the continent. With this foundation one would have said that we should have developed along graduate lines more rapidly than has been the case. Some of the American universities, however, have greatly outdistanced us in the development of graduate and research work. Let us hope that we shall overtake them. Our students who have received their bachelor's degree in one of the honours courses compare more favourably as a rule with those who have completed an undergraduate course in the corresponding department of an American university. The result of a comparison with the best product of the universities on the other side of the Atlantic is, however, not so favourable. The conception of a university at its best is on a somewhat higher plane in Europe than in America. The same is true also of the secondary school. A young man of exceptional ability being trained in Europe is likely to be somewhat in advance of where he would find himself at the same age if he were being trained in America. On entering Oxford or Cambridge, a student specialising in mathematics is about two years ahead of a student entering the University of Toronto in the same department, while he is just one year older. The discrepancy in classics is quite as great. This does not hold in case of the natural sciences, which receive less attention than mathematics and classics in the Public Schools of England. From what we have just said, however, it would appear that it should be possible to so modify the methods of instruction in our Canadian secondary schools as to save a year to our brighter boys by the time they are ready to matriculate. A comparison with results obtained on the continent would lead to the same conclusion.

The university attendance in the Province of Ontario in proportion to population compares favourably with that of any other country except Germany, after all due allowance has been made for inequality of university standards in different countries. Nevertheless, six out of seven pupils who pass the High School entrance examination never matriculate. About seven out of nine do not attempt the matriculation examination. (The figures here given are based on the results for the matriculation examinations during the five years 1910-14, and on the results for the High School entrance examinations during the five years 1906-1910). Among these boys and girls there are sure to be many who would profit by a university course. Much good material must here go to waste. Why should we not have in Ontario, or better still throughout Canada, a system of scholarships which would provide the highest possible education for the exceptionally gifted? Australia makes such provision for her gifted boys and girls. Why should we do less for ours?

(To be continued).

AN APPEAL
BY MERCHANTS, MANUFACTURERS, AND SHIPOWNERS OF THE UNITED KINGDOM.

WE have received from the National Association of Merchants and Manufacturers the following notice, together with a list of over 800 signatures, which appears to include most of the chemical manufacturers in the Kingdom:—

"We, the undersigned Merchants and Manufacturers of the United Kingdom, desire to endorse the weighty Appeal by leading Bankers issued on May 12, and to insist with them on the need of dealing promptly with the perilous situation in which the country is placed.

"The Appeal, which opens by recalling the Petition of the Merchants of the City of London addressed to the House of Commons in 1820, dwells on the parallel between the state of the country then and now.

"At the present juncture the following problems

seem to call most urgently for attention :—

An immediate and drastic reduction of expenditure is of vital importance.

The freeing of our trade and industry from the trammels imposed by the War is not less essential.

The interference with our commerce, whether by Parliament or by the Administration, must be stayed at once.

But it is perhaps even more important that the inhabitants of this country should be impressed with the absolute need for greater industry and greater thrift, so that the wealth annihilated by the War may be restored. Such restoration can only be accomplished by earning more and spending less.

"By these means alone shall we be able to bear the burdens from which we suffer, to regain the foreign trade essential to our prosperity, and to contribute to the well-being, not only of our own country, but of all other countries on which we are largely dependent.

"We invite our fellow-countrymen to join with us in impressing on the Government, on Parliament, and on the nation at large, the paramount importance of these great questions."

PROCEEDINGS OF SOCIETIES.

FARADAY SOCIETY.

June 22, 1921.

Prof. A. W. Porter, F.R.S., President, in the Chair.

"High Temperature Phenomena of Tungsten Filaments." Part I. By C. J. Smithels (for the *Research Staff of the General Electric Co*).

Two types of tungsten wire are in general use for lamp filaments. One is composed of pure tungsten, and the other of tungsten containing up to 1 per cent of a refractory oxide such as thoria. The crystal growth during burning has been investigated for both types. It is shown that the deformation of the filament which occurs during life is a function of the crystal growth. Crystal growth, which is suppressed in thoriated filaments occurs when the thoria is reduced. Thoria, and other refractory oxides, can be reduced by phosphorus vapour at a high temperature.

Part II. Deals with the chemical reactions which occur in gas-filled tungsten filament lamps when traces of the common gases are present in the filling gas. The types of failure which are produced in each case are described. The paper was illustrated by photomicrographs.

"A Simple Apparatus for Determining the Coagulations Velocity of Gold Sols." By Emil Hatschek.

The percentage of blue formed in coagulation of red gold sol is taken as a measure of the degree of coagulation. The percentage is determined by comparing the original red sol with a double wedge, one half consisting of the original sol, and the other of the completely coagulated blue sol. It is necessary that the latter should be coagulated by the same electrolyte as that used in the sol under examination, as the blues obtained with different electrolytes are not exactly alike. A number of determinations have been compared with V. Smoluchowski's formula for the coagulation velocity, and show good agreement for complete and fairly rapid coagulation.

The President then read a paper on the *"Variation of Surface Tension and Surface Energy with Temperature."*

"The Influence of Solvent upon Ionisation and the Accompanying Heat Effects." By S. M. Neale.

A determination by electrical conductivity methods of the ionisation of picric and paranitrobenzoic acids in mixtures of acetone and water. From the values obtained at 25° and 35° C., the heats of ionisation are calculated. In the case of picric acid, the heat of ionisation varies largely with the nature of the solvent, passing through a minimum at about 70 per cent acetone. In the case of paranitrobenzoic acid the heat of ionisation is sensibly zero both in water and in 44 per cent acetone, although in the latter solvent the ionisation constant has fallen to one-twentieth of its value in pure water as solvent.

"The Potention of the Iodine Electrode and the Activity of the Iodide Ion at 25° C." By A. McKeown.

The potential of the saturated iodine electrode in combination with the normal calomel electrode has been measured for various values of the concentration of the iodide ion. The results have been compared with those of other investigators, making use of the concept of activity coefficient, the activities of the iodide and of the tri-iodide ion in the various solutions have been estimated and compared with the values of the concentration of these ions. It is found that the activities of both ions increase less rapidly than their concentrations. From the results the normal potential of the iodine electrode is calculated to be +0·2454 volts, the normal calomel being taken as zero.

CORRESPONDENCE.

ETHYLSTANNIC ACID.

To the Editor of the Chemical News.

Sir,—In reply to Mr. Redgrove's letter in your issue of July 15, dealing with the nomenclature of the compound $C_2H_5.SnO.OH$, I wish to point out that the name *ethylstannic acid* is that adopted by the Chemical Society, and it does not meet with my own approval, as the reactions of the substance indicate that it is a compound of bivalent tin.

In a paper contributed a short time back to the Chemical News, on the corresponding methyl compound, I termed the substance methylstannic acid, following the nomenclature adopted in the abstracts of the Chemical Society's *Journal*, 1903, i., 470, and 1903, i., 802. The Chemical Society now favour the nomenclature criticised by Mr. Redgrove, viz., ethylstannic acid for the compound $C_2H_5.SnO.OH$; see also *Journal Chemical Society*, Abstracts, 1910, i., 724. This is to be regretted, since the bivalent nature of the tin in this class of substances is thereby obscured.—I am, &c.,

Gerald Druce.

NOTES.

INSTITUTE OF CHEMISTRY.—*Pass List.*—The following candidates have been successful in the July, 1921, Examinations, and have been duly elected Associates of the Institute:—Examination in General Chemistry: Campbell, Alan Newton, B.Sc. (Lond.); Doolan, James Joseph; Evans, Benjamin Beardmore, B.Sc. (Birm.); Hand, George Percy Terry; Jenkin, John Watson; Pugh, William; Ridge, Bert Pusey; Woolf, Sidney Samuel, B.Sc. (Lond.). Examination in Metallurgical Chemistry: Storer, George Paterson. Examination in Organic Chemistry: Kenyon, Frank; Sheldon, Francis Joseph, A.R.C.S., B.Sc. (Lond.). Examination in the Chemistry of Foods and Drugs, &c.: Martin, Charles William; Mooney, Paul Michael, B.Sc. (Lond.); Woodward, Miss Elsie. Examination in Chemical Technology (Soap, &c.): Smith, David Dow; (Coke Oven Practice, &c.): Whitaker, John Wilfrid, B.Sc. (Lond.).

WAGES AND EMPLOYMENT.—The serious nature of the depression and the effect of the coal stoppage which lasted throughout April, May, and June, may be measured by the extent to which employees have been thrown out of work or placed on short time. The following figures, which cover all classes of workpeople, but do not include coal miners, show the number of persons on the Live Registers of the Employment Exchanges on the dates given:—

December 31	756,823
January 28	1,065,320
February 25	1,218,218
March 25	1,413,751
April 29	1,854,059
May 27	2,122,496
June 24	2,178,000

The increase in the March figure over that for February is chiefly due to the re-registration of applicants who became entitled to a further period of benefit under the Unemployment Insurance Act which came into operation on March 3. The number of unemployed persons insured under the Unemployment Insurance Acts, 1920 and 1921, and the number of short-time workers in receipt of benefit on certain dates, together with the corresponding figures for December 31, are given below:—

Date.	Totally Unemployed.	On Short Time.
December 31, 1920	433,571	435,152
March 25, 1921	1,194,000	744,000
June 24, 1921	1,971,192	758,429

The Trade Union figure of unemployment, which is based on reports to the Ministry of Labour by Trade Unions with an aggregate membership of 1¼ millions, shows the following fluctuations:—

	Per cent.		Per cent.
January	6·9	April	17·6
February	8·5	May	22·2
March	10·0	June	23·1

The corresponding figure for July, 1914, was 2·8 per cent, and the average for 1920 2·4 per cent.—*Board of Trade Journal.*

TENDERS INVITED FOR DISINFECTANT.—The Municipal Council of Johannesburg invites tenders to be presented with samples not later than noon on September 1 next, for a six months' or, alternatively, twelve months' supply of fluid disinfectant. The approximate annual requirements of the Council are given as 5,000 Imp. gallons in drums containing 5 Imp. gallons. A copy of the specification, tender form, general and special conditions of tender, is available for inspection by United Kingdom manufacturers and suppliers on application at the Enquiry Room of the Department of Overseas Trade, 35, Old Queen Street, Westminster, S.W.1.—Department of Overseas Trade.

NEW COMPANIES.

The under-mentioned particulars of New Companies recently registered are taken from the Daily Register compiled by JORDAN & SONS, LIMITED, Company Registration Agents, Chancery Lane, W.C.2.

NAGELS & CO. (LONDON), LIMITED.—(175639)—Registered July 9th, 1921. 76a, Chancery Lane, W.C.2. To carry on the business of General Merchants, Chemists, Druggists, Drysalters, etc. Nominal Capital: £1,000 in 1,000 Shares of £1 each. Directors: V. G. Van Waasdyk, Malden Hall, Watford (Chairman and Managing Director), G. C. Gagan, 109, Inville Road, S.E.17. Qualification of Directors: £1. Remuneration of Directors: To be voted by Directors.

EGERTON CHEMICAL COMPANY, LIMITED.—(175613)—Registered July 8th, 1921. 19, Brazennose Street, Manchester. To carry on the business of Manufacturing Chemists. Nominal Capital: £1,000 in 1,000 Shares of £1 each. Directors: J. F. Key, 32, Oak Road, Higher Crumpsall, Manchester; A. Ferrie, 122, Lansdowne Road, West Didsbury, Manchester. Qualification of Directors: 1 Share. Remuneration of Directors: To be voted by Company.

MANCHESTER AND DISTRICT RADIUM INSTITUTE.—(175725)—Registered July 14th, 1921. Nelson House, Nelson Street, Manchester. To acquire Radio-active Materials whether containing Radium or Mesothorium or other Radio-active Substances of any description. Every Member to contribute a sum not exceeding £1 if necessary. Directors: Sir E. Holt, Woodthorpe, Prestwich; Sir W. Cobbett, Woodlands, Wilmslow; F. P. Nathan, Crumble Lodge, Swinton Park, Pendleton; G. M. Midwood, The Grange, North Road, Congleton; L. Pilkington, Firwood, Alderley Edge; Sir W. Milligan, Westbourne, Rusholme, Manchester; S. H. Renshaw, Beech Grove, Chesbam Bury; W. Armitage, Barthomley, Catherine Road, Bowdon.

T. H. SMITH (WISBECH), LIMITED.—(175644)—Registered July 9th, 1921. 1, Market Chambers, Market Street, Wisbech. To carry on the business of Agrihorticultural Chemists, Manufacturers and Dealers in Pulp, Jam and Preserves. Nominal Capital: £500 in 500 Shares of £1 each. Directors: T. H. Smith, 29, West Street, Wisbech; R. Scrafton, 1, High Street, Wisbech. Qualification of Directors: £1. Remuneration of Directors: To be voted by Company.

CATALYTIC CHEMICAL COMPANY, LIMITED.—(175760)—Registered July 16th, 1921. To carry on the business of Manufacturing Chemists and Druggists. Nominal Capital: £10,625 in 10,000 Preference Shares of £1 each and 25,000 Ordinary Shares of 6d. each. Minimum Subscriptions: 7 Ordinary Shares. Directors: W. H. Collbran, Elmley, Park Side, Wimbledon Common; J. Day, Derwent House, Wimbledon Park Road, S.W.19; W. R. Walkey, 52, Upper Richmond Road, East Sheen. Qualification of Directors: 100 Shares. Remuneration of Directors: £100. Chairman: £200.

LEIGHTON LABORATORIES, LIMITED.—(175834)—Registered July 20th, 1921. To carry on the business of Manufacturers of Chemicals of all kinds. Nominal Capital: £5,000 in 4,900 Cumulative and Participating Preference Shares of £1 each and 2,000 Ordinary shares of 1/- each. Directors: C. E. Bergin (Managing Director). Qualification of Directors: £100. Remuneration of Directors: To be voted by Company.

BARKER BROTHERS (SIMPSON CLOUGH), LIMITED.—(175757)—Registered July 16th, 1921. Simpson Clough Mill, Heywood, Lancashire. To acquire and carry on the business of a Bleacher' Dyer and Finisher. Nominal Capital: £70,000 in 70,000 Shares of £1 each. Directors; P. V. Barker, Simpson Clough, Heywood; F. Barker, Simpson Clough, Heywood; E. Barker, 149, William Street, Heywood; H. Barker, Springfield, Hopwood, Heywood. Qualification of Directors: 50 Shares. Remuneration of Directors: To be voted by Company.

W. A. WILSON & SONS, LIMITED.—(175870)—Registered July 21st, 1921. To acquire and carry on the business of Chemical and Colour Merchant. Nominal Capital: £4,000 in 4,000 Shares of £1 each. Directors: C. Collins, 36, Leysfield Road, Hammersmith, W; W. A. Wilson, St. Breock, Vicarage Road, Woodford Bridge, Essex; P. Wilson, St. Breock, Vicarage Road, Woodford Bridge, Essex; A. C. Stevens, School Green, Freshwat r, Isle-of-Wight. Qualification of Directors: £500. Remuneration of Directors: £100 each.

New Patents.

This List is specially compiled for the *Chemical News* by Messrs. Rayner & Co., Registered Patent Agents, of 5, Chancery Lane, *London, W.C.2., from whom all information relating to Patents*, Trade Marks and Designs can be obtained gratuitously.

Latest Patent Applications.

19053—Aitchison, L.—Purification of chromium ores and residues containing chromium oxides. July 14.
18949—Allsebrook, W. A.—Manufacture of lead chromate pigments. July 13.
19217—Cooper, C.—*Manufacture of sulphate of ammonia.* July 16.
18806—Klencke, H.—Process for production of sulphuric acid. July 12.
19220—Marr, J.—Manufacture of benzanthrone derivatives. July 12.

Specifications published this Week.

128939—Nitrogen Corporation.—Process of synthesizing ammonia.
166036—Heisch, G. F.—Ammonium sulphate saturaters.

Abstract Published this Week.

Glycerine.—Patent No. 164034.—An improved process of producing glycerine has been patented by Mr. A. T. Hocking, Carhampton House, Four Oaks, Sutton Coldfield, and Lilly C. H., 29, Carlyle Road, Edgbaston, Birmingham, both in Warwickshire. The glycerine is produced by fermenting sugar solutions containing a mixture of about equal weights of alkali bisulphite and sulphite. The mixed sulphites may be added in successive small quantities to a proportion corresponding to the percentage of glycerine desired, the proportion of acetaldehyde and alcohol being greater the less proportion of sulphide; and the liquid may be maintained approximately neutral by successive additions of alkali bisulphite solution *or by increasing the proportion of bisulphite in the additions of the* mixed sulphites. In an example in which the maximum glycerine yield was required, 311 gallons of a solution of crude cane sugar, equivalent to 788 lb. glucose were fermented by 40 lb. of yeast at a *temperature of 35-37° C. for 9 days, and during the first five days 176* gallons of mixed sodium sulphite and bi-sulphite solution equivalent to 545 lb. Na_2SO_3 were added in doses, first of 40 lb. and then of 30 lb. mixed salts in 16 gallons of water. In this way, 336 lb. glycerine, 172.2 lb. of acetaldehyde, and 37.4 lb. alcohol were produced.

Messrs. Rayner & Co., will obtain printed copies of the published specifications and will forward on post free for the official price of 1/- each.

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GEO. H. MORLEY,
Secretary.

REQUIRED small amount of working capital to open up a Lead mining property in north of England. Ore already located and property favourably reported on by A.I.M.M. Particulars on application. Write Box 227, Willings, 125, Strand, London, W.C.2.

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PATENTS, TRADE MARKS. Handbook and advice free—B. T. King, British and U. S. Regd. Patent Attorney, 146a, Queen Victoria St., London. 35 years reference.

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THE CHEMICAL NEWS.
VOL. CXXIII., No. 320[illegible]

NOTE FROM THE EDITOR.

NOW that the dislocation of work is over, and the readjustment of effort brought about by the death of Sir William Crookes has in great measure become permanent, the writer, whose connection with Sir William is tolerably well known, has decided to collect together and complete some notes and enquiries that were under consideration during the last few years of work in the Laboratory at Kensington Park Gardens. The following is the first of such notes, and others will follow in due course.

ABSORPTION OF HEAT BY SOLUTIONS. For the Microscopic Projection Apparatus. (From the Private Notes of the late Sir WILLIAM CROOKES).

Some little time ago I had occasion to project on a screen images of sections of crystals and microscopic objects mounted in Canada balsam. The objects had to be highly magnified so as to be seen on a 20ft. screen, and it was necessary to concentrate a strong beam of electric light on the object. Several slides were destroyed by the Canada balsam boiling and charring, and experiments were then instituted to see if solutions could be found that would transmit sufficient light without risking injury to the object by too great heat.

The projection apparatus was fitted as for an experiment, and instead of an object, the blackened bulb of a thermometer was introduced. *With no liquid intervening, the thermometer* would have been destroyed at once, for the heat was sufficient to ignite cloth, brown paper, and wood. A glass cell, 50 mm. from back to front, was accordingly interposed, and various liquids were filled into it. The arc was kept as constant as possible, and the beam tempered by the liquid was allowed to play on the bulb of the thermometer for ten minutes. The maximum temperature was reached in two or three minutes.

The following Table gives the strength of the different solutions employed, and the maximum height attained by the thermometer.

Solutions employed	Temperatures recorded.
Distilled water	197° C.
Ammonia alum, saturated solution ...	170° C.
Ammonio-ferrous sulphate, 3oz. to the litre	143° C.
Ferrous sulphate, 3oz. to the litre ...	138° C.
Copper sulphate :—	
⅛oz. to the litre	118° C.
¼oz. to the litre	104° C.
½oz. to the litre	93° C.
1oz. to the litre	87° C.
2oz. to the litre	80° C.

From this Table it is seen that water and solutions of alum are very poor obstructors of heat, sufficient getting through to injure a microscopic slide in the focus of the beam. Copper sulphate solution is a good interceptor for radiant heat, and it can be used safely as weak as ⅛oz. to the litre, at which strength the colour is almost imperceptible on the screen with ordinary objects, and it does not much interfere with the colours in polarisation experiments with crystals, while the comfort of using a concentrated beam of electric light on the object with no fear of injuring it is worth a slight diminution in the brilliancy of the colours.

NICKEL ISOTOPES.

By F. H. LORING.

IN view of Aston's recent announcement in *Nature* (June 23, 1921) that nickel has isotopes of masses 58 and 60, I hereby amend a portion of the Table given in the CHEMICAL NEWS (August 27, 1920), to read as follows:—

Elem't.		n × He	a	b	c	d		Isotopes & Prop. No.	'Calc.' & Exp. Mass.
N	=	14×4+				$\ddot{4}$	= 60	$\ddot{4}^3$ × 60	= 58·67 58·68
		14×4+		2			= 58	2^3 × 58	

It will be seen on referring to the original Table that one of the *a-b-c-d* values was irregular with respect to a preceding one, but by this change it becomes quite regular. The dots over the 4 *indicate* that this figure as a whole is not to be cubed, but that it has to be taken as made up of four units, thus: $1^3+1^3+1^3+1^3=4$, *as in some other cases*—see original Table. The retention of the indices is for mathematical uniformity.

After introducing this amendment and comparing all my values of the Table with all those now published by Aston, it will be seen that there are 21 whole-number values in exact agreement with *experiment and two departures from experiment* by one unit only in each case; namely, Li 6 and B10. Introducing the extreme values for magnesium by Dempster (see *Science*, December 10, 1920), which are 24 and 26, raises the agreement figure to 23.

Referring to the above departures, it will be noted that they are *even* numbers, whereas the valencies are *odd*. The valency rule thus seems to break down, but it is a curious fact that except for these two exceptions practically all the other isotopes of the Table are in accordance with the rule. Cobalt appears to have valencies of 2 and 3. Its calculated isotopes are 57 and 59—see Table. Nitrogen, though not isotopic, is a notorious exception to the rule, but this element is exceptional in other respects.

I have tried to account for the nitrogen irregularity by regarding N as truly bi- and quadrivalent, and by assuming that ammonia, for example, was a mixture of isotopic *molecules* NH_2 and NH_4 in equal proportions, the mean being apparently NH_3; but, needless to say, this scheme did not seem justified from the study of various experimental data. There are no doubt surprises in store in connection with these matters which may turn out to be as startling as the breaking up of the nitrogen atom by Rutherford.

UNIVALENT OXYGEN. PREPARATION AND OXIDATION OF MESITOL.

By C. W. PORTER and F. H. THURBER.

WHEN Gomberg isolated triphenyl-methyl and produced evidence that other radicals are capable of independent existence (Gomberg, *Ber.*, 1902, xxxv., 3915), he revived the hopes expressed by Dumas, Kolbe and Frankland, and gave a new

impetus to research in organic chemistry. At the present time several compounds of trivalent carbon are known; but with the exception of Kohler's triphenyl-indyl (Kohler, *Am. Chem. J.*, 1908, xl., 217) they all belong to the triarylmethyl class. The search for new types of radicals, and especially those representing unsaturated conditions in elements other than carbon, has not been very successful, except in the discovery of compounds of divalent nitrogen derived from hydrazine and carbazole. Wieland found that tetra-anisyl hydrazine in benzene has an abnormally low molecular weight; develops a colour which deviates from Beer's dilution law; and forms an addition product with nitric oxide. One or two other substituted hydrazines displayed similar properties (Wieland, *Ber.*, 1912, xlv., 2601). Branch and Smith obtained a derivative of carbazole which dissociates into radicals of divalent nitrogen (Branch and Smith, *Jour. Am. Chem. Soc.*, 1920, xlii., 2405).

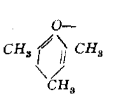
Porter and Borgstrom prepared tetraphenyl-diarsine (Porter and Borgstrom, *ibid.*, 1919, xli., 2048) and corresponding derivatives of phosphorus and although these products absorbed oxygen from the air and exhibited other evidences of unsaturation, their properties could be accounted for without assuming any measurable dissociation. A lead compound bis (lead triphenyl), $(C_6H_5)_3Pb\text{-}Pb(C_6H_5)_3$, acquires a colour when heated, but gives no other evidence of change in structure, and the corresponding derivative of silicon does not dissociate at all (Schlenk, *Ber.*, 1909, xliv., 1179).

An attempt to isolate an oxygen radical was made by Pummerer (Pummerer, *ibid.*, 1914, xlvii., 1472; Pummerer and Cherbuliez, *ibid.*, 1914, xlvii., 2957), who oxidised several naphthol derivatives with potassium ferricyanide and other reagents, thus obtaining tautomeric products corresponding in composition to the original naphthols or to the peroxides derived from them). Some of these bodies gave coloured solutions deviating from Beer's law; and the molecular weights were lower than the calculated values for peroxides. The many possible intramolecular rearrangements, however, made uncertain any deductions with respect to the structures of these oxidation products.

Hunter and Woollett have expressed the opinion (Hunter and Woollett, *Jour. Am. Chem. Soc.*, 1921, xliii., 142) that the complex amorphous oxides which they obtained from trihalogenated phenol salts are condensation products of residues containing univalent oxygen; and that in the process of building up these massive structures some of the oxygen valences remain free.

In our work, which has been in progress during the past two years, the aim has been to eliminate some of the possibilities for intramolecular rearrangements, and particularly the shift of a group from phenol oxygen to an *ortho-* or *para-* carbon; to accomplish this we worked with a simple phenol, mesitol, (2,4,6-trimethylphenol), in which the positions *ortho* and *para* to the hydroxyl are occupied by methyl groups.

The compound was oxidised by silver oxide and from a mixture of oxidation products we obtained a red crystalline compound melting at 224° to 226°. It has the composition of the peroxide we hoped to obtain; its reactions, however, indicate that it is a quinhydrone. The following formulas represent possible structures of the primary oxidation product.



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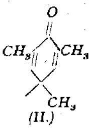

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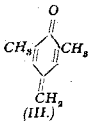

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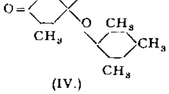

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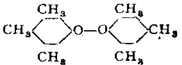
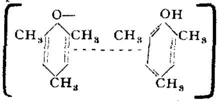
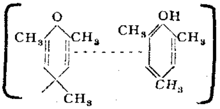


(V.)

Formulas I., II., and III. are excluded, for the molecular weight of the product is above 225, whereas these formulas represent compounds having the molecular weight 135. Moreover, the quantity of any reducing agent required to discharge the red colour of a solution of the compound is only half the amount theoretically necessary to reduce I. or II., and only one-fourth the amount required for Formula III. Formulas IV. and V. are also unsatisfactory, for, although they are in fair agreement with the determined molecular weight, their complete reduction would require the same quantity of reducing agent per grm. of substance as required by Formula I. or II. We believe the red crystals represent a quinhydrone composed of equimolecular quantities of unoxidised mesitol, and an oxidation product corresponding to Formula I. or II. The nature of the union between the two nuclei is unknown, but may be similar to that existing between quinone and hydroquinone in the ordinary quinhydrone formed when hydroquinone is oxidised. Until further evidence is secured, its structure may be represented as :—



or

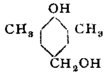


Regardless of the nature of the tie between the two nuclei, it is evident that the compound containes an odd or unpaired electron—the outstanding characteristic of a free radical (Lewis, *Jour. Am. Chem. Soc.*, 1916, xxxviii., 770)—for it is re-

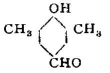
duced by the addition of only one hydrogen atom per mol of the compound. It represents therefore an addition to the very limited number of known types of odd molecules. Several years ago, G. N. Lewis suggested that such compounds should be capable of independent existence. To quote his words: "If proper protection against intramolecular rearrangement be provided, we may predict that di-aryl substituted hydrogen peroxide will be prepared, which in turn will dissociate into mono-aryl oxide, ArO, the odd molecule, or free radical, of univalent oxygen" (Lewis, *Proc. Nat. Acad. Sci.*, 1916, ii., 586).

Our oxidation product crystallizes in fine red needles and in benzene forms a deep red coloured solution containing less than 0·1 per cent of the solute. It is even less soluble in alcohol, and insoluble in water. It is rapidly reduced to colourless products by an alcoholic solution of potassium or sodium hydroxide, but is fairly stable in a very dilute acid solution of alcohol. Stannos chloride, titanous chloride, and ferrous sulphate rapidly discharge the colour of an alcohol solution of the compound, the original colour being restored by treatment with silver oxide. The quantity of any reducing agent required to discharge the colour corresponds to the calculated value for the quinhydrone formula or half the quantity required for Formulas I., II., IV., or V. The crystals dissolve in concentrated sulphuric acid, giving a very deep red solution, the colour of which is discharged by diluting with water. Nitric acid converts it at once into colourless products. These colourless products we have not yet identified.

The red compound is totally unlike the oxidation products of mesitol obtained by Bamberger (Bamberger, *Ber.*, 1903, xxxvi., 2030) and Thiele (Thiele and Eichwede, *Ann.*, 1900, cccxi., 366). Bamberger used Caro's acid, and Thiele employed amyl nitrite as the oxidising agent. The formulas assigned to their products are:—



and



Both are colourless and water-soluble.

The calculated molecular weight for the quinhydrone is 271. The values we obtained were between 225 and 250. On account of its slight solubility we could not get a freezing-point depression equal to 0·01°, and we do not consider the molecular weight determinations sufficiently accurate to justify the conclusion that the low values are due to dissociation. On the other hand, the measurements are good enough to indicate that undissociated molecules contain two mesitol residues.

Experimental.

Preparation of Mesitol.—Mesidene (2,4,6-trimethylaniline) was made from 1,2,4,-xylidine and methyl iodide by an application of the Hoffman rearrangement. The success of the method depends upon the purity of the reagents, control of the temperature, and the time of heating. Pure 1,2,4-xylidene was obtained from the mixed isomers (commercial product) by precipitation of the acetate with glacial acetic acid. The crystals were pressed, washed with acetic acid, and dried. The free xylidine was liberated from the crystals by means of sodium hydroxide solution, separated from the water layer and distilled.

Equimolecular quantities of 1,2,4-xylidine and pure methyl iodide were poured into Pyrex bomb tubes packed in ice. After standing for two or three hours, the tubes, now containing the viscuous amber-coloured quaternary ammonium compound, were sealed, heated during the course of an hour to 260°, and held at that temperature for three hours. (The optimum temperature for the rearrangement seems to be 260°. At temperatures much lower the change does not occur, and at higher temperatures there is considerable charring. We used an electric autoclave with a thermoregulator, and maintained a temperature that did not vary more than 3° or 4°.) The red, waxy, or semi-crystalline product was transferred to a flask and neutralised with sodium hydroxide solution. The oily layer, mesidine, was separated and distilled under reduced pressure.

Mesitol.—The mesidine was diazotised in the presence of an excess of dilute hydrochloric acid solution and warmed. Mesitol separated as a red oil. It was removed from the water layer, dried with sodium sulphate, and distilled under 10 cm. pressure. On standing the distillate crystallised. Recrystallisation from 20 per cent alcohol gave pure white feathery crystals melting at 69°.

Oxidation of Mesitol.—Flasks containing 25 g. of moist silver oxide, 5 g. of mesitol, and 500 cc. of benzene, were sealed and shaken in a thermostat at 50° for four hours.

Each solution acquired a deep red colour, and a fine red crystalline compound precipitated. On evaporation the filtered solution yielded a small quantity of the red compound, but the major portion was obtained by elutriation from the residual mixture of silver oxide and the red compound remaining in the flask. The crystals are much lighter than the other components of the residue, and can be washed out with benzene. The substance is insoluble in water, and only slightly soluble in alcohol, chloroform, and ether. It melts at 224—226°.

Analyses.

Subs. G.	H_2O G.	CO_2 G.	H. Per cent.	C. Per cent.
0·1050	0·0756	0·3113	8·00	80·80
0·1200	0·0853	0·3520	7·90	80·00
0·1425	0·1045	0·4206	8·15	80·50

Calculated for quinhydrone: 8·48, 80·81.

Molecular Weight.

Cryoscopic method. Solvent, Benzene, K=50.

Subs. G.	Solvent. G.	Temp. °C.	Mol. Wt.
0·0322	100	0·007	230
0·0270	100	0·006	225
0·0900	230	0·008	245

Calculated for quinhydrone: 271

Reduction with Hydrazine (Hunter and Woollett, *Journ. Am. Chem. Soc.*, 1921, xliii., 138).

Subs. G.	Vol. N_2. Cc.	Temp. °C.	Barom. Mm.	Wt. N_2 liberated by 271 G. substance.
0·1105	2·7*	15	760	7·72
0·1240	3·1	20	758	7·68
0·1000	2·2	15	760	6·95

Calculated for quinhydrone: 7·00

Reduction with $SnCl_2$

$SnCl_2$ in dilute HCl standardised by titration with $KMnO_4$ solution containing 0·5000 g. of $KMnO_4$ per litre.

10·00 cc. of $SnCl_2$ = 15·60 cc. of $KMnO_4$. Subs., 0·03, in 80 per cent alcohol reduced by 4·6 cc. of $SnCl_2$ solution. Equivalents of reducing agent required for 271 g. of substance = 1·02. Calculated for quinhydrone: 1·00.

Reduction with $FeSO_4$.

$FeSO_4$ in dilute H_2SO_4 standardised by titration with $KMnO_4$ (0·5000 g. per litre). 9·70 cc. of $FeSO_4$ = 17·05 cc. of $KMnO_4$. Subs., 0·052 in 80 per cent alcohol reduced by 7·10 cc. of $FeSO_4$. Equivalents of reducing agent required for 271 g. of substance = 1·03. Calculated for quinhydrone: 1·00.

Summary.

Mesitol in benzene solution at 50° is oxidised to a red crystalline compound which is unsaturated and is readily reduced to colourless products.

Its molecular weight indicates that it contains two mesitol nucle.

Its reduction is accomplished by half the quantity of reducing agent that would be required if all the oxygen were quinone or peroxide oxygen

It is reduced to a saturated product by addition of an uneven number of hydrogen atoms or other electro-chemical equivalents, indicating that it has an impaired or odd electron.

The properties of the compound are accounted for on the basis of a formula containing an oxidised mesitol residue possessing either univalent oxygen or trivalent carbon more or less firmly held by an unoxidised molecule of the phenol.—*Journal of the American Chemical Society*, May, 1921.

FUEL PROBLEMS OF THE FUTURE.*

By Sir GEORGE T. BEILBY, F.R.S.

CIVILISATION on its physical side is based on fuel. Of all the powers of Nature which have been turned to his use and convenience by man, "Fire" stands out with a distinction which is unique. The kindling of the first fire of dried leaves and branches by our prehistoric ancestors marked the beginning of the transfer of this mighty power from the gods to man; and new possibilities of prodigious import were opened up. With fire at his command, a new dividing line was established between man and the lower animals, and a higher and more social standard of living became possible. The horrors and dangers of the darkness of night were greatly mitigated, social instincts were aroused through the nightly gathering round this new source of light and warmth, while imagination and thought were stimulated. The charred stick supplied the budding artist with his first pencil; while the glowing embers were the laboratory furnace in which the coming chemists and metallurgists made their first observations on the effects of heat on rocks and stones.

Fire—first automatically and then deliberately became the test to which all materials were submitted. The arts of the craftsman were based on these observations; the smelting of metals, the very opening the way to new adventures. It is bending of wood, the singeing of skins, the melting of gums, and the boiling of water, started a whole train of new possibilities—each step in disno exaggeration to say that the practice of observation and experiment on which the physical science of to-day is founded had their origin in the first fire kindled by man.

In the management of the wood fire the first lessons in the properties of fuel were learned. The flaming stage, followed by the steady and more concentrated heat of the glowing embers, naturally led to the collection of more massive embers by the control of the earlier stages of combustion—thus leading up to charcoal burning, by which the worker in metals was supplied with an ideal fuel for his operations. Thus the carbonisation of raw fuel as a means of raising the availability of the potential therms it contains, had its origin in the remote past.

It is far from our present purpose to follow through the ages the romantic history of the association of fuel with civilisation. Enough has been said to justify my opening remark that civilisation on its phsical side is based on fuel. This interrelation has developed new features during and since the war; and the future production and use of fuel in this country has become closely associated with social ideals which involve the raising of the standard of living among the mining class. This, indeed, is the most pressing of the fuel problems of the near future. Can coal again be produced at a price which will enable this country to take its place in the markets of the world, while the present standards of wages and working hours are maintained? Careful and impartial students of the economic facts of the situation tell us that this is not possible. Merely to regain an entrance into the iron and steel markets of the world, we are assured that the coal used in this industry must not cost more than 18s. to 20s. per ton. For the great transport services of the country, a slightly higher cost for coal might be faced if all the available measures of economy in its use as fuel are adopted. It is obvious that, without a greatly increased output per man, the earnings of the miner cannot be maintained at their present figure.

This end can only be attained by genuine cooperation between the coalowners and the miners; any half-heartedness on either side will in the long run lead to failure. How is such cooperation to be secured? The miners have pinned their faith to nationalisation as supplying the solution of the problem. The nationalisation which the more extreme section have in view appears to involve the handing over of the direction and control of the industry to nominees of their own, who would in effect be pledged to regard the wage-earners' interests as paramount.

While the nation is in sympathy with the raising of the standard of living of the miners, and the improvement of working conditions in the mines, it has no belief that nationalisation would supply a commonsense and practical solution of the problem. The nation also realises that no system of bureaucratic control would adequately replace the individual and collective effort which is necessary for the development of this complicated industry.

The significance of the patience and self-sacrifice of the consumers of coal right through

*Delivered in the theatre of the Institution of Civil Engineers, London. Inserted by favour of the *Gas Journal*, June 29, 1921.

the difficult times which culminated in the strike of the past months, appears to have been missed or misinterpreted by both miners and mineowners, and to some extent also by the Government. This remarkable patience on the part of the whole British public does not mean that they are either ignorant of, or indifferent to, the future availability and cost to them of the fuel on which their daily lives must depend both directly and indirectly. If a permanently higher cost of fuel must be faced, then its availability must be correspondingly increased.

To take only one aspect of this question of "availability" which affects every consumer, from the highest to the lowest—the quality of the coal as it is raised to the surface and distributed by rail and road—this is a matter which at present is entirely in the hands of the mineowners and the miners. Every householder knows that the quality of the coal he or she receives has greatly deteriorated during and since the war. Stones and other inferior materials have been received and paid for as coal at the greatly enhanced prices of the day. The very fact that this burden is most widely felt by individuals renders it unsuitable for dealing with by statistics. For our present purpose, therefore, the experiences of the large consumers can be more usefully considered.

The gas undertakings of the United Kingdom are responsible for the distribution of the heat derived from about 20 million tons of coal per annum. This, in round numbers, is not less than *one-eighth of the total amount of coal consumed* in the country. The experiences of these undertakings as regards the depreciation in the quality of coal they have received during and since the war have been freely disclosed and discussed by their engineers and directors; and on the strength of these representations the Board of Trade agreed to sanction a very substantial reduction in the calorific value of the gas delivered and paid for at the old rates by the consumers. Even with this relaxation in quality, the gas undertakings found it difficult, and in some cases impossible, to maintain adequate supplies of gas to their consumers, while the coke in which the whole of the inert and valueless material in the coal was concentrated was rendered greatly inferior as a fuel.

During the inquiry of the Fuel Research Board into the question of gas standards, they were in close touch with this subject; and my present remarks are based on first-hand knowledge. As a result of our recommendations, the Board of Trade adopted the "therm" of 100,000 B.Th.U. as the future unit of charge to the consumer for the gas he receives; and I merely refer to the change at this stage in order to demonstrate the logical application of this principle to the question of the quality and price of coal. If the gas undertaking is in future to be paid only for the therms delivered to the customer, it is entitled to throw at least a portion of its responsibility on the coalowners and miners by paying only for the potential therms received in the coal, and not for inert and inferior materials which are not only valueless and detrimental to economical working in the retort-house, but lower the value of the coke produced.

Among other large consumers of coal, electricity generating stations occupy a very important place. Of the total cost per unit in the generation of electricity, the larger proportion is due to the fuel consumed. This cost has been trebled or even quadrupled since 1914—largely, no doubt, owing to the direct rise in the price of coal, but also to a substantial extent through the deterioration in quality of the coal supplied. By the kindness of Sir Alexander Kennedy and of Mr. Herbert Jones, the Electrical Engineer of the London & South-Western Railway, I am in possession of the working results of the first quarter at two important generating stations in London. These figures will be again referred to in another connection. For our present purpose, I will only draw attention to the coal experiences at these stations. In the case of the Central Electric Supply Company, the calorific value of the coal received for thirteen weeks averaged 10,582 B.Th.U., cost 45s. 2d. per ton, and its ash content was 18·4 per cent. The weekly ash figures ranged from 16·3 to 20·1 per cent. In the winter of 1914-15, the corresponding figures were: Calorific value, 10,800 B.Th.U.; cost per ton, 14s. 6d.; ash content, 13 per cent. The ash excess on the coal supply during the present year was therefore 5·4 per cent, or rather more than 1cwt. per ton.

At the Durnsford Road power house of the London & South-Western Railway at Wimbledon, the average calorific value of the coal received was 10,900 B.Th.U., and the ash content 16 per cent.

Examples of this kind could be multiplied indefinitely from the experiences of private firms and public institutions. But the foregoing are sufficient to establish my point, which is that in view of the stage reached by the national coal problem, the time has come when the vital interests of the consumers must be reckoned with in any settlement that is arrived at. These interests require that the mineowners and miners must alike realise that their responsibility is not met by the output of mere material at the pit head and its distribution to consumers by road or rail. Whether this material is to be consumed in its raw state as fuel, or whether it is to be converted into fuels of higher availability by gasworks or other carbonising and gasifying agencies, what counts is its thermal value. To the miner it may seem a revolutionary proposal that he should be paid by the therms he sends to the surface; but as he himself possesses views in connection with the development of his industry involving a treatment of the national fuel problem from an entirely new and revolutionary point of view, he cannot logically ignore the effects on the consumer and on the nation at large of the permanently increased cost of fuel which must result if his claims for a higher standard of living are to be realised.

To my mind it would be a serious set-back to our civilisation if the only solution of the economic problem involves the production of coal at prices which are insufficient to ensure for the miner a steady amelioration of the conditions under which he lives and brings up his family; and I for one would be prepared with good heart to face the working out of the more efficient use of fuel which is absolutely necessary if a higher price is to paid for coal. This, however, would only be on one condition—that there is genuine co-operation of coalowners and miners, not only in the organisation of output on modern lines, but

in the endeavour so to sort out and prepare the output by screening and washing the coal at the pit-head that the consumer is only called upon to pay carriage on the actual fuel value received. The gas or electric undertakings are certainly entitled to press home to the miner the fact that, as the consumers of gas and electricity only pay them for "therms" or "units" received, they in turn should pay the coalowners and miners on the same basis, though at a cost per therm which will leave a reasonable margin of profit on their operations.

Probably the iron and steel industry will be most severely handicapped by any permanent increase in the price of coal, as fuel enters into its operations to so large an extent. The opinion has been expressed by experts in this industry that, though a reduction to 18s. or 20s. per ton in the price of coal suitable for the making of iron and steel might enable the industry to recommence, it is doubtful whether it coulld ultimately hold its own in the markets of the world. To ensure this, it is considered that it would be necessary for coal to return to the neighbourhood of its pre-war price. It has been suggested (Coal Conservation Committee, Ministry of Reconstruction, 1918, pp. 77-81) that a considerable saving of fuel might be effected by so grouping the elements engaged in the production of finished steel—coke ovens, blast furnaces, gas producers, steel furnaces, and rolling mills—that the heat from all sources could be pooled at a common centre of heat and power. By this means it was considered that any excess of heat available at one stage might be made available at other stages in which an excessive demand existed. In this way it was believed that the consumption of coal per ton of finished steel might be reduced to 35cwt. per ton. If an ordinary figure of consumption of 45cwt. be taken, then a saving of 10cwt. of coal per ton of steel might result from grouping. With coal at 18s. per ton the saving would amount to 9s. per ton of steel. But this estimate takes no account of the large capital which would have to be sunk in scrapping and replacing existing works.

The future of British iron and steel production is obviously so closely associated with the future price of coal, that no outsider is in a position to solve the problem. We can say, however, that substantial fuel economies are possible, though the extent to which this would justify a higher price for coal is still quite uncertain.

Before considering in technical detail some of the fuel problems which are more immediately before us, it may be well to pass in review the fuel position of the world, as it is disclosed by the most recent figures of production. For our present purposes our survey must be on broad and simple lines, which will enable us to grasp the whole question in due proporiton and in its true perspective. Proportion and perspective, as the exponents of the doctrine of relativity might remind us, depend entirely on the point of view of the observer. The facts and figures of the fuel resources of the world are the common property of the experts of all civilised nations. They may be regarded as being like the immutable laws of Nature; but the proportion and perspective in which these facts and figures range themselves are different for the observers and commentators *of each of these nations. In our own survey, shall be wise to have in our minds some recognition of these widely different points of view.*

In Great Britain, as a maritime nation, we cannot, either on political or commercial ground ignore the points of view of other nations inside or outside the circle of the Empire.

An interesting review of the world's coal supply in 1920 is given in the United States Geological Survey. The total output, including brown coal and lignite, amounted to 1300 million metric tons. This is within 3 per cent of the maximum output which was reached in 1913 and 1918. Of this total output—

	Per cent.
The United States of America produced...	45
Great Britain and the British Empire produced	22
Germany produced	19
Other countries, ranging from 2½ per cent downwards, produced	14
	100

One of the most significant features revealed by this survey is the remarkably rapid development in the winning and use of brown coal and lignite in Europe and particularly Germany. The output in Germany in 1919 had reached the huge figure of 93·8 million tons; but this was overtopped in 1920 by an output of 111·6 million tons—an increase in one year of nearly 18 million tons. The total European output in 1920 amounted to 140·7 million tons, made up as follows:

	Million tons.
Germany	111·6
Czecho-Slovakia	19·7
Jugo-Slovakia	2·5
Austria	2·5
Italy	1·6
Netherlands	1·4
France	1·0
Spain	0·5

The output of ordinary coal in Germany for 1920 was 140·8 million tons. The brown coal industry in that country is of old standing; and its rapid development in recent years is based on sound knowledge and experience. Though in its natural state a less concentrated fuel than bituminous or anthracite coal, brown coal has many points in its favour. The chief of these is the low cost at which it can be won as compared with ordinary coal. Where extensive deposits of great thickness occur, these can be worked opencast, and excavated by machinery. The winning of brown coal is thus on an altogether different basis from coal mining, with its deep and costly underground roads and workings, which involve heavy costs for timbering, pumping, and ventilation. The manual labour required is much smaller in amount for a given output, and is of less highly specialised type; while the special dangers and uncertainties of coal mining are practically absent. The capital charges being mainly on surface roads and on excavating machinery—are relatively light, as compared with the heavy initial and permanent charges involved in the sinking and equipment of shafts or mines. Brown coal, though it contains from 40 to 60 per cent of water, is to-day by far the cheapest source of thermal units. Its further manufacture by drying, briquetting, and carbonisation, can be carried out close to the point

of excavation, and under conditions favourable to production on a large scale, and therefore at a low cost.

The glowing accounts of this development which have appeared in the technical Press during the past two years may have struck us as exaggerated; but the solid fact remains that the output of lignite in Germany last year was 111 million tons. Germany has already faced the fuel problem of the future so far as she herself is concerned.

In view of the hard facts and figures which are now before us, it is not surprising that Germany's example is being followed, not only in Central Europe, but in Victoria and in Canada. In Victoria, extensive deposits of brown coal exist in Central Gippsland, which are estimated by Mr. H. Herman, the Director of Geological Survey, to contain 30,000 million tons. The main deposits near Morwell are hundreds of feet in thickness, and lend themselves admirably to opencast working on an enormous scale. Considerable progress has already been made in the development of these deposits; and since the commencement of operations in 1916, 400,000 tons of brown coal have been mined and sold. When the excavating methods become more perfectly organised, it is anticipated that the coal will be produced at the mines at 2s. 3d. per ton. It contains from 40 to 50 per cent of water; so that in heat value two tons is equal to about one ton of ordinary coal. A 50,000 kilowatt generating station is being installed at Morwell for the transmission of current to Melbourne. Though a considerable market appears to exist for the coal as it is mined, it is intended to establish briquetting and carbonising plant at the mines; so that fuels of higher availability will be produced from the raw coal. In 1920, a sample of this coal was received here, and experiments on its carbonisation were carried out at the Fuel Research Station.

In the Dominion of Canada, experiments are in progress on the briquetting and carbonisation of the brown coals of Manitoba and Saskatchewan. These experiments are being carried out under the auspices of the Dominion Government and of the Government of the Province of Saskatchewan.

Somewhat allied to the lignite problem is that of the development of peat as a fuel. The Dominion Government of Canada is keenly interested in this question; and I shall have something more to say on the subject at a later stage. Germany also is preparing for important developments, some of which are described in the *Engineer* for April 22, 1921. The Wiesmoor plant, which has been in use since 1910, is now regarded as obsolete; but during the ten years it has been in use, much valuable experience has been gained in the winning and use of peat. The average fuel consumption is stated to be from 2·7 to 3 kilos. of partially dried peat sods per k.w. hour, and the cost of the peat is taken at 5 marks per ton. It is now proposed to establish a line of generating stations fired by peat extending from Königsberg in the east to Wiesmoor in the west.

The world's output of brown coal and lignite in 1920 was about 143 million tons, or 11 per cent of the total coal output of 1300 million tons. From the European point of view, the significance of this fact must not be gauged in terms of this moderate percentage. According to the extent to which Germany can meet her own requirements for heat and power by the development of lignite, peat, and water power, the output of her coal mines will be set free for export, and she will thus take a more important place in the markets of the world. The coalowners and miners of this country would be well advised to keep an eye on the development of brown coal and lignite in Germany and elsewhere.

(To be continued).

UNIVERSITIES, RESEARCH, AND BRAIN WASTE.*

By J. C. FIELDS, Ph.D., F.R.S.

(Concluded from p. 77).

THE waste of brain in this world is a tragedy of the first order. There is none greater. This was brought home to us with peculiar emphasis during the war. When Moseley was killed at Gallipoli scientists everywhere felt a sharp pang. Here was a young man who had crossed the threshold. He had just had time to prove his genius. Almost at his first attempt he left his imprint on the science of physics, and great things were expected of him. His sudden cutting off did a great violence to the sense of the fitness of things in the minds of those who knew what a loss it meant to science. The toll of Trinity College, Cambridge, in the war was in the neighbourhood of 2,000. Of these, some had already been productive, and others gave great promise. The most gifted of our young men went overseas, and many of them will never return. Among the latter were two of gold medallist standing in my own Department. The sacrifice of a young man of exceptional ability seems to accentuate the unreason and injustice of warfare. Why should he not have been permitted to fulfil his natural destiny, to lead an intellectually productive life, and perhaps add a permanent increment to the heritage of the race? Yet the same sacrifice of exceptional gifts, the same waste of brain power, is going on regularly in our midst in peace times and we pay no attention to it. What is possible in this regard I have illustrated by the history of mathematics in America. Successive generations of potential mathematicians were wiped out. They never knew what struck them. Their contemporaries never knew that nature intended them to be mathematicians. The story of the Dockyard Schools is full of suggestion as to the waste that must be going on. We pause to think when we hear of a man like George Green, who was discovered at 40, graduated at Cambridge at 44, and died at 48, after leaving his permanent mark on the history of mathematics and physics. It is said that his later years were saddened by the realisation of the fact that the greater part of his life had been wasted. How many George Greens are there who die before 40? How many who are not discovered before 48?

There is one general formula which will enable us to avoid all waste of brain, but we should endeavour in every possible way to salvage all we can. It would, no doubt, be helpful to have the advantages of a university or higher technical education presented from different view-points to

*Reprinted from the *Transactions of the Royal Canadian Institute* February 1921.

the pupils in the secondary schools, preferably by visiting lecturers. Their studies, too, should include something of a biographical or narrative character touching on the lives and work of the great scientists. This might even with advantage be introduced into the elementary schools. Matter could readily be selected which would not be lacking in romance.

Some adequate reference it seems to me should be made to science in the teaching of history in the schools. Modern history, as I understand it, is an account of how a people, starting out under certain conditions at a given time in the past, have arrived at where they now find themselves. The most important agent involved in the transition, the largest factor by far concerned in modifying the conditions of living during the past two centuries, has been science. Is it not of the first importance that every boy and girl should be made aware of this fact?

By stimulating the interest of the pupils of the preparatory schools in science, by visualising university opportunities and by establishing a system of scholarships such as we have already referred to, we could doubtless increase considerably the number of students of ability in our universities. Those who do not go to the university, but leave the elementary or secondary school to earn their living, would at least carry away with them a certain respect for science and a recognition of the fact that the university has a useful function to perform in the life of the community. This would later on have its effect in helping to create a public opinion which would react more favourably to proposals for financial aid to universities and science.

A university should be sufficiently staffed to care for the needs of its students. Our own University is undermanned. The tutorial classes should be smaller. This is no good reason, however, why the members of the staff should be overworked. Junior instructors, who have research inclinations, should be given a chance to show the mettle that is in them. The more mature men, who have already proved themselves, should be given time for research. Only yesterday I was talking to a member of the staff who told me that for three weeks past he had been working till three in the morning and that for seven days in the week. The man in question is a research worker, but the work referred to had nothing to do with research. This is, of course, exceptional, and it will not ordinarily be necessary for my colleague to work so strenuously. Even so it is a little inconvenient. The same man, too, worked till midnight daily during the last month of the vacation getting the materials required in his laboratory in readiness for the opening of the term. I asked him whether he received any pay for work overtime. His reply was an incredulous smile which, interpreted, meant how could any member of a university staff be so ingenuous as to ask such a question.

The case I have cited is an extreme one to be sure. There are plenty of members of the university staff, however, who have more than enough to do, and there is none who has not enough to keep him busy. Of this the layman can rest assured. Further staff, of course, would mean more expense, but the Province would be well paid for its extra outlay.

There should be a larger number of places for research men in Canada. There should be more positions for them in the universities and more in the industries outside. The University of Toronto has begun to develop along research lines, and in the course of time, no doubt, much good Canadian brain-power will be salvaged which would otherwise go to waste. The projected Institute for Research at Ottawa will absorb some of the men trained by the University for research. It is to be hoped that the demand from the industries will grow. It might be well also to have such men in charge of the science departments in the high schools, and to encourage their research inclinations by furnishing them with adequate laboratory equipment. Something of this sort, I understand, it is proposed to do in England. (A provision in the Education Act enables local authorities to meet the cost of research work of educational value conducted by teachers in the schools.) This would all tend to conserve Canadian brain for Canada, and would check the leakage to the United States and other countries. Of the 15,000 living graduates of the University of Toronto, 1,700 are located in the Republic to the south of us. Between 400 and 500 others are domiciled abroad. McGill's loss to the United States is 1,500 out of 6,700 graduates.

It has been suggested that research professors and research associate professors be appointed in the departments of natural science of the University of Toronto, their duties to consist primarily in the prosecution of research on their own account, and in the training of young men of selected ability for research. The aggregate of these research men would be known as the research staff in natural science of the University of Toronto.

To me it appears that the organisation of such a group would, in addition to creating greater effectiveness within the university, have a two-fold benefit without. On the one hand, it would remind the laymen that there exists a body of men in the world whose business it is to advance knowledge, and on the other hand it would impress on them the fact that the University is not an institution whose sole function is to purvey knowledge, but that it has also another and quite as important function, namely, to add to knowledge and to train young men in order that they may add to knowledge in their turn.

The war has been wasteful of brain power. It has, however, taught us its value. In the work of reconstruction nothing can be of more importance than conserving and realising on the brain power of the nation. In this work the universities must play the leading role. If in our reconstructed country we shall have reduced brain waste to a minimum and increased brain output to a maximum, we shall have raised the greatest of all memorials to our boys who sacrificed themselves in France and Flanders in order that Canada should be saved from determination by Germany. It is for the Canada whose destinies will be determined by Canadians that they fought and died, and the Canada that is to be will be their monument. Let us make the monument a great and noble one. May it be worthy of those whom it commemorates.

GERMAN COMPETITION.

THE "Report on the Economical and Financial Situation of Egypt," published by the Department of Overseas Trade (H.M. Stationery Office, Imperial House, Kingsway, W.C.2), contains much information that might be studied with profit by British manufacturers, particularly in reference to foreign competition and the requirements of Egypt. From a mass of important notes we select the following statement, which speaks for itself.

"German stationery is being sold at many Italian and Greek shops at very low prices, and the material appears to be of a good class. For five sheets of notepaper and five envelopes only 5 milliemes or 1½d. is charged.

German glassware and chinaware imports increased very greatly during the latter months of 1920; cutlery of a cheap order is also being imported in large quantities, as well as table services of every kind and design. The majority of the teaspoons, sugar-tongs, and other small accessories of the table are, however, of a very glaring and vulgar order. Silver-gilt birthday spoons are selling at P.T.125 a dozen, sugar-tongs at P.T.65 each, and nickel-plated plates at P.T.30 each. Razors are sold at an average price of P.T.55 each, which cannot be called remarkably cheap.

German drugs are returning to the Egyptian market in large quantities, including the original saccharine tablets, Messrs. Bayer's aspirin, and "Odol," manufactured by their original producers. Saccharin and aspirin are being advertised in all the local papers; the latter is sold in bottles containing 24 five-grain tablets (standard English weight).

German dyes, *e.g.*, synthetic indigo and other coal-tar dyes, are also returning to this market in large quantities, the quantity being more than double, and the value nearly treble, that of imports from the United Kingdom.

Among recent patents taken out will be observed (1) the name of J. A. Reidel, Aktiensgesellschaft Chemical Manufacturers of Britz, 1-38, Reidelstrasse, Berlin, viz., the word "IDRAG" printed, written, or stamped, in any size, manner, shape, or form; and any letters black, white, or red, used in respect of their chemical, medicinal, photographic and lithographic products; also the word "GENOSAN" as above in respect of their medicinal products; dated 12/1/21: (2) Badische Anilin & Soda Fabrik of Ludwigshafen; specification of invention having for title "Préparation stable à base d'indigo blanc"; dated 10/1/21.

German pianos, mouth-organs, and other musical instruments are being freely advertised in Egypt, the prices for mouth-organs being very low indeed. The exporter of the latter is Albert Wordlish, of Stettin, who is sending in addition large quantities of cigar-holders, pipes, &c., to Egypt, also at very low prices, owing to the low rate of exchange.

It is unfortunate that, owing to German firms being able to accept such very low prices, they have succeeded in wresting fairly large contracts from United Kingdom exporters for railway material required by the Egyptian State Railways, and other kinds of material and plant required by other Government Departments, *e.g.*, light railway permanent way for use in connection with oil workings by the Department of Mines on the Sinai Coast. Unless British steel firms are prepared to make a big sacrifice, in spite of prices at present ruling in Sheffield, and to guarantee within a specified period, in order to keep their hold on the market for Egyptian Government contracts, they must not be surprised to see all future orders secured by German, Austrian, or Belgian firms, particularly for railway material and rolling stock.

German (Bosche) dynamos have been arriving in great numbers and were quickly sold owing to the low price demanded, and also to the fact that either United Kingdom exporters had apparently overlooked the Egyptian market for some months, or had not delivered them in sufficient quantities for its needs, as British dynamos appear to be very scarce at present.

Quantities of German fittings and spare parts are returning to this market; also hand-spanners, wrenches, and other hand tools are being sold in most of the machinery shops. In this connection it is to be regretted that a British engineer spent five days recently trying to buy a Briggs T-head spanner, which he required for use at the Egyptian Government oil workings on the Sinai Coast, and, having finally failed to buy a single one, was compelled, owing to the urgency of the work required, to purchase a German article.

The products of Krupps, the A.E.G., and Borsig Wolf & Co., are sold by the Technical Supply Co. of Alexandria, a company formed for that purpose.

German bicycles of the "Ankard," "Eros," and "Oppeln" makes were imported in fair numbers during 1920, but their sale is not very extensive. The two first-named arrive as a rule without tyres, and are sold by agents at £E.10 a piece with tyres, and £E.6 without. The "Oppeln," with half-gallon petrol tank and motor on frame with springs, is sold at £E.35.

New German electric motorcars of the "Adler" make are arriving in good numbers, also without tyres, and are being sold at £E.120, being of the very small type. Mercedes and Daimler cars are being sold at prices ranging from £E.1,500 to £E.3,000.

It is interesting to note that nearly all the tyres fitted to these German motorcars and bicycles on arrival here are of British manufacture, and in the case of the "Eros" bicycle, a British-made tyre, 28×1½in., is the only one extant in this market which will fit it.

Nearly all the films shown in Egypt have hitherto been American or French productions, but of late many German films have appeared, and it must be admitted that they have proved of a very superior order. It is to be hoped that United Kingdom producers will make an effort to show their films in this country, where they would be sure to be appreciated.

NOTICES OF BOOKS.

Journal of Indian Industries and Labour. Vol. I., Part 2. Printed at Calcutta by the Superintendent of Government Printing, India (Can be obtained in London of the following Agents:—Messrs. Constable & Co., Kegan Paul, B. Quaritch, P. S. King & Sons, H. S.

King & Co., Grindlay & Co., Luzac & Co., W. Thacker & Co., T. Fisher Unwin, Wheldon & Wesley).

The second part of Vol. I. of this *Journal* contains much that is of interest. Sir Thomas Holland contributes an article on the principles which govern the grant of mineral concessions in India. His discussion of the grounds on which the mineral policy of a Government has to be determined explains the reasons for restrictions which are apt sometimes to appear unnecessarily irksome to those engaged in the development of the mineral resources of a country. The article concludes with a very useful summary of the rules for the grant of prospecting licences and mining leases which are at present in force in British India.

An interesting account of the Rajputana salt industry, with particular reference to the salt works on the Sambhar Lake, is given by Mr. P. C. Scott O'Connor, an officer of the Northern India Salt Revenue Department, who has studied the history of Government control over salt production and has had considerable personal experience of the actual work of producing salt for the market.

Mr. J. W. Meares, in an article entitled "The Hydro-Electric Survey of India," explains in a lucid manner the potentialities of India in the matter of sources of water power. He discusses the various methods by which water can be harnessed in order to produce power for the development of industries and the provision of public conveniences without interfering with its function of irrigation. An account is given of the origin of the hydro-electric survey of India, of its results up to date, and of the limits within which its work is confined. Mr. Meares' remarks on the proper utilisation of electricity will be of use to those who have to weigh the comparative advantages of this and other sources of power.

Mr. Clow contributes a thoughtful article on the subject of "Factory Children and Education." The history of legislation relating to the various restrictions on the employment of children in factories is given and the comparative merits of the two schools of thought, one of which favours the prescription of educational tests before employment and the other the putting of compulsion on employers to provide education during the period of employment in a factory, provides an interesting contribution to the discussion of this difficult subject.

The subject of "The Hide, Skin, and Leather Trades and Boot and Shoe Manufacturing in India" is treated by Sir Henry Ledgard, who was until recently the Honorary Adviser to the Government of India on Boot Production. A detailed account is given of the methods introduced into the manufacture of boots for the Army in India during Sir Henry Ledgard's short term of office. The article concludes with a summary of the position of the leather and boot industries in India at the present time.

An interesting address on the subject of chemical research for the development of industries in India, which was read by Dr. E. R. Watson at the last meeting of the Indian Science Congress, is reproduced as an article in the *Journal*. Dr. Watson pays particular attention to the possibilities of producing in India the essential munitions of war which he claims should be the foremost consideration in the industrial policy of the country.

An outline of the present position of technical and industrial education in Bengal is the subject of a short article by Mr. W. H. Everett, which deals with education under the heads of civil engineering, surveying, mechanical and electrical engineering, mining, weaving, commercial education, and art.

Other items of interest are a summary of information regarding industrial disputes in India during the first quarter of the year, miscellaneous notes on various subjects, including the bleaching of shellac, the investigation of cotton stalks as a paper-making material, three short notes on subjects of industrial interest contributed by Sir Alfred Chatterton, and a statement showing the kind, quantity, and cost of stores purchased in India by Government during the three official years ending 1919-20. A new feature of the *Journal* is the publication of reviews of recent publications.

A notice announces that eight bulletins of *Indian Industries and Labour* have now been published, and seven more are in the press.

CHEMICAL NOTICES FROM FOREIGN SOURCES.

Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences. Vol. clxxiii., No. 3.

"The Distribution of Electrons in Heavy Atoms."—By MM. A. Danvillier and L. de Broglie.

"The Diffraction of X-rays by Liquids."—By M. A. Debierne.

"The Resistivity of the Monosulphide to Monoselenide of Thallium."—By M. H. Pélabon.

"The Magnetic Properties of the Metals of the Alkaline Earths in Combination."—By M. Paul Pascal.

"The Rôle of Gaseous Impurities in the Catalytic Oxidation of Ammonia Gas."—By M. Eugene Decavrière.

"The Preparation of Calcium Carbide by Calcium Ammonium and Acetylene."—By MM. L. Hackspill and E. Botolfsen.

"A New Reaction of Ammonia."—By M. Couat D. Zenghelis.

"A New Method of Preparing Sodium Derivatives of True Acetylenic Hydrocarbons."—By M. Picon.

"The Polymerisation of Glucosanes."—By MM. Amée and Jaques Pictet.

"The Nitro and Amido Derivatives of Methyl Ethyl Benzene."—By M. Alphonse Mailhe.

NOTES.

Market for Chemicals in the Netherlands East Indies.—His Majesty's Commercial Agent in Batavia (Mr. H. A. N. Bluett), has forwarded to the Department of Overseas Trade the official returns of the import of chemicals into the Netherlands East Indies for the first two months of 1921. The chemicals named are alum, caustic soda, sodium carbonate, iron sulphate, calcium carbide, and copper sulphate. Except in the case of the

last two, the returns show a very considerable falling-off in trade with Great Britain in 1921 as compared with that of 1920, with a corresponding increase on the part of Germany. Further particulars can be obtained by application to the Department of Overseas Trade, 35, Old Queen Street, Westminster, S.W.1.

Production and Industry (Iron and Steel).—The production of iron and steel, which in 1920 almost approximated the 1913 figures, shows a large decline in the first six months of 1921, the actual figures, together with the corresponding figures for 1920, being as follows:—

	Pig Iron.		Steel Ingots and Castings.	
	1920. Tons.	1921. Tons.	1920. Tons.	1921. Tons.
January	665,000	642,100	754,000	493,400
February	645,000	463,600	798,000	483,500
March	699,000	385,500	840,000	357,600
April	671,000	60,300	794,000	70,600
May	739,000	13,600	846,000	5,600
June	726,000	800	845,000	1,900*
Total	4,145,000	1,565,900	4,877,000	1,412,600

* This refers to castings only.

It will be seen that a considerable decline took place before the beginning of the coal dispute, but the decline in the United States was equally serious, and no improvement in output in that country is yet visible:—

U.S. Output of	Pig Iron.	Steel.
1920 Monthly average ...	3,077,000	3,392,000
1921 April	1,193,000	1,441,600
1921 May	1,221,000	1,500,500
1921 June	1,065,000	1,192,000

Both countries were feeling the effects of general world depression and of price-cutting by Belgian and German competitors. Under these influences makers of pig-iron in this country are at present quoting prices as low as £8 10s. per ton. After the first few weeks of the coal dispute, practically every blast furnace in the country was closed down, but with the close of the coal dispute, a slow recovery is now expected, although its course is dependent on a moderate price of coal.—*Board of Trade Journal.*

Tellurium Tetraiodide.—Its existence, long doubted, has been demonstrated by M. Damiens. It is in form of small black brilliant crystals, 4 to 5 mm. long. Density at +15° is 5·05. Little soluble in alcohol and acetone, it is insoluble in ether, chloroform, and carbon sulphide. Though proof against humid air, it is slowly attacked by cold water, and decomposition in hot water liberates hydroiodic acid almost immediately decomposed. It is suitable for preparation of numerous derivatives of tellurium, but its speedy decomposition restricts the chemical actions in view to low temperatures.—*Comptes Rendus,* May, 1921.

American Chemical Society.—The Fall Meeting of the American Chemical Society will be held with the New York Section, Tuesday, September 6 to Saturday, September 10. This will probably be the largest Meeting of the American Chemical Society that has ever been held. Aside from the 2500 members of the New York Section itself, many thousands are within a four or five hours' ride of New York. In addition to the usual features, we shall have as guests at this time a considerable number of British and Canadian members of the Society of Chemical Industry, who will have held their Annual Meeting in Canada, will be greeted at the border by the Governor of the State, and will arrive in New York on Wednesday morning, September 7. After being the guests of the American Section of the Society of Chemical Industry at a luncheon on September 7, they then become the guests of the American Chemical Society for the remainder of the week. We expect three or four hundred of these British and Canadian friends, besides three or four thousand from the American Chemical Society. All members of the American Chemical Society are invited to the meeting in Montreal, beginning August 29. A further reason for this being a large and successful meeting is the opening of the National Exposition of Chemical Industries on September 12, immediately after the close of our meeting. A great many guests from all over the United States who visit this Exposition each year, will come a few days earlier to attend the Meeting of the American Chemical Society.

Mr. Douglas H. Ingall, M.Sc., chief assistant to Prof. Turner, Birmingham University, has been appointed Principal of the County Technical College, Wednesbury, in succession to Mr. Walter Macfarlane, F.I.C., who now retires as Emiritus Principal after 25 years service with the Staffordshire Education Committee.

Distillation of the Leaves of Green Plants.—The distillation of the leaves, immediately after gathering without addition of water, under reduced pressure at 60° C., gives ethyl alcohol, acetic aldehyde, nitrous acid. The experimenter, M. Mazé, did not find formic aldehyde. The leaves of the haricot and maize contain, in very fine weather, acetylmethylcarbinol, those of the elder free hydrocyanic acid and glycolic aldehyde, those of the poplar lactic aldehyde. Formation of acetylmethylcarbinol, glycolic and lactic aldehydes is closely allied with assimilation of carbonic acid. Maize and haricot leaves are destitute of acetylmethylcarbinol in the morning, but contain it in increasing quantities during days of sunshine; on rainy and cold days they are completely destitute. Haricot leaves contain coumarine in the evening and not in the morning.—*Comptes Rendus,* clxxi., No. 26.

Calcic Cyanamide.—The first idea of manufacture of calcic cyanamide is due to Berthelot, then Franck and Caro. It was produced on an industrial scale in Italy subsequently, the carbide being treated in retorts superheated on the exterior with nitrogen. The yield was bad, owing to superheating against the sides. It was then noted that the reaction being exothermic, it sufficed to heat the mass at one point to 800° to 1000° C. to start the reaction. This heating was first obtained with a carbon heated by electricity. In the more recently constructed plant, electricity is yet utilised, but for heating on the circumference, which gives a better start to the reaction. Trials have also been made with tunnel kilns, but in spite of great improvements, nothing very satisfactory has been obtained. Thus a product with 19 to 22 per cent nitrogen is produced, whereas theory gives 30 per cent; the impurities are mainly lime, carbon, and unattacked carbide. It is estimated that 1700 kilogrms. of cyanamide with 20 per cent nitrogen can be manufactured with

1 H.P. Cyanamide, with the water of the soil, gives urea, and then carbonate of ammonia, which are oxidised by nitrifying bacteria into directly assimilable nitrates. For employment in agriculture it is hydrated to destroy quick-lime and carbide, then granulated as far as possible to prevent formation of dangerous dust. Unfortunately, a really practical method of granulation has not yet been found. Cyanamide can also be mixed with other fertilisers like superphosphates taking certain precautions to prevent retrogradation.—*L'Engrais*, June 3, 1921.

New Patents.

This List is specially compiled for the *Chemical News* by Messrs. Rayner & Co., Registered Patent Agents, of 5, Chancery Lane, London, W.C.2., from whom all information relating to Patents, Trade Marks and Designs can be obtained gratuitously.

Latest Patent Applications.

19376—Badische Anilin & Soda Fabrik.—Production of thymol. July 18.

19531—Dreyfus, H.—Manufacture of solutions, compositions, preparations, of articles of cellulose derivatives. July 20.

19669—Gluud, W. W.—Method of extracting sulphuretted hydrogen from gases. July 21.

19848—Scottish Dyes, Ltd.—Colouring matters of the napththalene series. July 23.

Specifications published this Week.

166228—Marks, E. C. R.—Recovery of fluorine as hydrofluoric acid.

166289—Head, C. J.—Process for the manufacture of chromic oxide and sodium sulphide from sodium chromate.

166425—Renck, .—Production of casts from ferrous sulphide.

145053—Akt Ges. für Anilin-Fabrikation.—Manufacture of ortho-oxy-ayo-disayo-dye-stuffs.

Abstract Published this Week.

Purifying Fats, Etc.—Patent No. 164115.—Mr. H. Bolman of 1, Alsterdamm, Hamburg, Germany, has obtained a Patent for an improved process of purifying fats and fatty oils from fatty acids, resins, mucilaginous and bitter substances, etc., by treatment in counter current with a solvent for fatty acids, etc., but not for glycerides. A series of extraction vessels is used, and the solvent and fatty oil are separated from each other before passing to the next vessels. Solvents specified are methyl alcohol, ethyl alcohol, amyl alcohol, acetone, acetic ester, diluted or not with water to ensure a sufficient difference in the specific gravity of the solvent and of the oil. When fats are treated, the temperature is maintained sufficiently high to ensure liquefaction. In the apparatus, rape or other oil from a reservoir, is passed continuously into the highest vessel of a series of washing vessels, and three times the volume of 96 per cent alcohol from a reservoir into the lowest vessel, while the agitator works continuously. The mixture in each vessel passes continuously to a separator opposite by pipes, and separates into two layers, the alcoholic solution from other separators passing respectively to washing vessels, and that from another separator through a pipe to a still, while the oily lower layer passes from separators to washing vessels and that from another separator to a still for the removal of residual alcohol. A temperature of 20-30° C. is maintained throughout. In a modified apparatus, treatment and separation take place in the one series of vessels, no agitators being employed, but retarding means such as Raschig rings, are used to ensure mixing and separation, and the separated oil and solvent flow to the next vessels through siphons.

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THE CHEMICAL NEWS.
VOL. CXXIII., No. 3201.

COAL WASTAGE IN TANK BOILERS.
ITS CAUSES AND PREVENTION.

By W. H. CASMEY, of Holdsworth & Sons, Ltd., Bradford.

THE wastage of human life and coal are caused by neglecting the laws of combustion, and consequently such losses are preventable, the loss of life being due to lack of air, and that of coal wastage for the very opposite reason—too much air.

Whatever types of tank boilers are used, *Cornish, Lancashire, or Yorkshire*, the factors governing their duty and efficiency are:—

(*a*) The correct proportion of air and coal to give the highest workable furnace temperature, approximately 2750° F.

(*b*) A standard ratio of 2 to 1 between the size of grates and smallest section area through which the products of combustion are to pass, between the ends of the furnaces and chimney bottom; depth of bottom flue half diameter of boiler; width of side flues one-seventh diameter of boiler.

With the above conditions and a minimum of brains between the coal heap and boiler furnaces, there will be no difficulty in securing an overall efficiency of 80 per cent or even more; there are of course, many minor details to consider, but every works engineer knows his own plant, and should be fully capable of dealing with it successfully, and the purport of this article is to show in a simple practical way, how, if we but get hold of the governing principle of economical steam production, we can not only save coal, but produce healthier surroundings for all.

The Law of Mathematics shows that twice 2 equals 4, and that 4 times 9 equals 36, and no argument can change the results; if, however, we make an error in our calculations, giving the answer as 35 instead of 36, we at once blame ourselves for the mistake, and not the mathematical rule, and this is the method to adopt in the boiler house, which is self-evident from the following illustrations.

To burn 1lb. of ordinary steam coal so that no waste shall take place requires 12lb. of air, and these elements combined give a CO_2 reading of 19·2 per cent., the furnace temperature being 4000°; and it is well to remember that the temperature of combustion is a constant, but much too high for steam raising purposes.

For good steam practice, the theoretical weight of air should be increased 50 per cent, thus making the proportions of 18lb. of air to 1lb. of coal; but this additional 6lb. of air, as already inferred, does not affect the temperature of combustion, but at once reduces the temperature of the furnaces from 4000° to a workable and useful temperature of, say, 2750°, and in this case the products of combustion contain 13 per cent CO_2; therefore, by increasing the air supply 6lb., the CO_2 is reduced 6·2 per cent, and that of the temperature 1300°.

Experience indicates, however, that in general practice we allow about 30lb. of air per lb. of coal, and with this 12lb. additional air supply, the CO_2 is only 7 per cent, and the furnace temperature 1750°, showing in this case the additional 12lb. of air reduces the CO_2 a further 6 per cent, and the furnace temperature an additional 1000°; it is therefore nothing besides pure neglect in not attending to the supplies of air and coal delivered to the furnaces being proportional for practical combustion, which causes fuel wastage.

Assuming we are working a boiler at 120lb. working pressure, the temperature of the steam will be 350°, and with 18lb. of air per lb of coal the difference in temperature between the water side and fire side of the boiler plates will be 2350°; but with air and coal in the proportion of 30 to 1 the difference will be only 1400°, which in practice means that one square foot of grate in the first case radiates as much heat per unit of time as 2⅓ square feet will radiate in the second case, and which can be further illustrated by saying, with the 18 to 1 proportions of air and coal, 15cwt. of coal will evaporate as much water as 20cwt. will do when the air and coal are in proportion of 30 to 1.

Briefly, the furnace temperature is always proportionate to the ratio between the air and coal supplied, and the heat transmitted to the water governed by such temperature; we therefore have practical demonstration that the chief factor contributing to coal wastage is excess air over that required for practical combustion, and economy will be secured when the same care is taken in producing heat as in producing every article we manufacture, *i.e.*, correct proportions and the results will then be right every time.

In working any steam plant, or even when attending to the domestic fires, this broad fac should be recognised, that the first gases liberate from a new charge of coal will not ignite at a lower temperature than 900°; therefore stoking should be done when the fires are clear and bright, and it will be found impossible to then produce black smoke; in fact, the emission o smoke from a chimney top spells inefficiency a the chimney bottom. Black smoke, it may als be useful to remember, contains two grains o carbon per cubic foot of gases, and as generall 400 cubic feet of air is supplied per lb. of coal black smoke takes away about 11 per cent of th coal used, *i.e.*, during a black smoke period.

Instead of the conditions briefly indicated a necessary for giving an overall efficiency of 8 per cent, it is generally found that the boile house is the one place where chaos reign supreme, as boiler efficiencies range from les than 50 per cent to over 80 per cent; the latte figure will be attained by probably not more tha 3 per cent of our steam plants, throughout th country the average of which probably does no exceed 60 per cent, indicating an annual loss o nearly 50 million tons of coal, and the cause o this huge wastage, as before stated, is due t more excess air than to careless stoking, such ex cess being caused by conditions over which th boiler attendant has no control.

It will be quite clear, even to the lay mind that the weight of coal burned in a given time governed by the weight of air passing throug the furnaces in that time, and yet we find that Lancashire boiler 7ft. diameter has 4 sq. feet c grate area to each square foot of outlet for th products of combustion to pass through; that similar type of boiler 8ft. diameter has a rat

of 3·5 to 1, and in a boiler 9ft. diameter, the ratio is 2·7 to 1, and if the 4 to 1 ratio is correct, the other two must be wrong.

The reason for these variable proportions between areas of furnaces and outlets for the gases was brought about by the introduction of tapering the back ends of the furnace flues 50 years ago, and which has had the effect of not only reducing the duty of the boiler, but also its efficiency by making it possible for 2·7 square feet of grate in one boiler to burn as much coal as 4 square feet in another of the same type, though the chimney draught is the same.

Years of experience have proved that the correct ratio between grate areas and outlets from the furnace flues for the products of combustion should not exceed 2 to 1, and under such conditions each square foot of grate in a 7ft. diameter Lancashire boiler would give the same evaporation as 1 square foot of grate in a boiler 9ft. in diameter, and the same applies to Lancashire boilers of all sizes, hence the need for establishing a fixed standard of grate suitable for boilers of all diameters, as is done in the Yorkshire boiler with most satisfactory results, both in duties and efficiencies each square foot of grate in any sized boiler giving equal evaporation.

We know the proportions of air and coal for producing a given temperature; we know the ratio between grate and outlet from the boiler for the products of combustion to pass through for securing this temperature, and that heat transmission is proportional to the difference in temperature between the furnace and fire sides of the boiler plates; also that a square foot of plate transmits double the number of heat units in a unit of time when the water above it is actively boiling, than when stagnant. Knowing these facts and others, such as radiation, &c., there is no excuse for wasted coal, and if the recent stoppage of the coal mines has taught us the value of burning coal correctly, the country will eventually benefit, though the lesson has been a most expensive one.

A NEW PHOTOGRAPHIC METHOD OF RENDERING THE SOLIDITY OF OBJECTS IN SPACE.

(PHOTO-STEREO-SYNTHESIS).

By F. F. RENWICK, A.C.G.I., F.I.C., F.R.P.S.

MONSIEUR LOUIS LUMIÈRE, to whom photographic science and practice are already deeply indebted for several epoch-making inventions, chief among which may be mentioned the practical realisation of kinematography and the invention of the famous Autochrome colour plate, has recently worked out an entirely novel method of obtaining photographic reproductions of solid objects which give remarkably lifelike impressions of relief. Hitherto the only satisfactory method of doing this was by the aid of the stereoscopic camera and stereoscope. Monsieur Lumière's new method is unlikely to become popular, but is undoubtedly very ingenious, and possesses great scientific interest, so that the striking example of his work which the Scientific and Technical Group Committee has been able to obtain from Monsieur Lumière for display at the Society's forthcoming Exhibition will be sure to excite attention both of members and of the general public. The fact that the specimen so kindly lent us is a portrait of the Postmaster-General, Mr. Kellaway, taken on the occasion of his visit to the Lyons Fair, will also doubtless add to the interest of the exhibit.

The means by which these pictures are made was described in a communication to the French Academy of Sciences in November last, and published in the *Comptes Rendus* (clxxi., 891), and a translation of this paper appeared in the ***British Journal of Photography*** for February 25 last (lviii., 110), so that it is unnecessary to describe the method in detail. The principle of the method, however, consists in the taking of a succession of photographs with a special camera, whose lens and plate-holder are both kept moving during each exposure. The motion of the sensitive plate is so adjusted to that of the lens that the images of all objects in one particular plane remain stationary on the sensitive plate, while the unsharp images of objects in other planes, before or behind this, move to a greater or less extent, and so fail to produce a recognisable image on the plate. The lens is first sharply focussed and exposure made on the part of the object nearest the camera, and then, before each succeeding exposure, the camera is moved bodily forward on rails so as to bring into sharp focus a somewhat *deeper plane of the object, till the whole thickness* of it has been dealt with.

In practice, Monsieur Lumière has used 18×24 cm. plates, and produces bust portraits half life-size. The lens is carried by a star-shaped panel, and is given a circular motion of 8 cm. diameter by the revolution of four cranks and spindles when driven by the simple belt and pulley arrangement. Somewhat longer cranks at the back of the camera carry the plate-holder, which is revolved in a circle of 12 cm. diameter by the same means.

In the case of a half-size portrait like that of Mr. Kellaway, Monsieur Lumière finds that six successive exposures suffice to give a satisfactory *rendering of solidity*.

From these negatives six very thin positives are made and arranged one behind another in a grooved frame in proper order and correctly spaced in accordance with the advances made by the camera between the successive exposures. A diffusing glass behind the asemblage of positives serves to produce even illumination from a lamp at the back of the whole.

To view the picture properly, it is necessary to stand straight in front of it and to direct the gaze normally to the surface from a distance of several feet. In addition to the method by which this and other similar portraits have been produced, Monsieur Lumière has also described another most interesting means by which these striking effects of solid relief could be produced. This second method, which is also described in the original paper referred to, is remarkably interesting for the reason that it foreshadows the possibility of producing full scale copies of maps, drawings, or other plane surfaces of any size with a small lens. Owing to the fact that sufficiently accurately made Porro prisms were not available, Monsieur Lumière failed to get satisfactory results by this method, but it is to be hoped that one or other of our skilled optical instrument makers will undertake their production and open up the new possibilities which the idea appears to offer.—*Photographic Journal*, August, 1921.

THE RELATIVE VOLUMES OF THE CHEMICAL ELEMENTS.

By HAWKSWORTH COLLINS. Continued from Vol. cxxii., p. 77.

THIRD deduction.—The experimental facts concerning the following 76 molecules demonstrate that one relative volume of H is 15·25 at 15° C., for, whether Cl, Br, I, NH_2, NO_3, SH, C_2H_5, C_3H, CO_2CH_3, $CO_2C_2H_5$, $CO_2C_3H_7$, CO_2H or OH (13·29) in such molecules as those numbered 1—115 be displaced by H, the volume of this H-atom is always the same.

No.	Name & Chem. formula.		Vols. of parts.	Theor. S.G.	Observed S.G.	
150	Me Cl	H—CH_2—Cl	15·25—(16·42)—23·01	0·924	0·920 18° Vi.	0·929 13° Vi
	Et Cl	H—$(CH_2)_2$—Cl	15·25—$(16·42)_2$—23·01	0·907	0·851 12° Rm.	0·923 15° P
	Pr Cl	H—$(CH_2)_3$—Cl	15·25—$(16·42)_3$—23·01	0·897	0·896 19° L.	0·893 15° P
	But Cl	H—$(CH_2)_4$—Cl	15·25—$(16·42)_4$—23·01	0·890	0·887 20° Lb.	0·897 14° L
	n-Pent Cl	H—$(CH_2)_5$—Cl	15·25—$(16·42)_5$—23·01	0·885	0·883 20° Lb.	0·896 0° Pr
	Hep Cl	H—$(CH_2)_7$—Cl	15·25—$(16·42)_7$—23·01	0·878	0·874 18° Sc.	∴ 0·877 15°
155	Oc Cl	H—$(CH_2)_8$—Cl	15·25—$(16·42)_8$—23·01	0·876	0·878 15° P.	0·850 C.

In the following M stands for methylene (CH_2) both in the formula and in the relative volume. Its volume is always 16·42.

No.	Name	Chem. formula	Vols. of parts	Theor. S.G.	Observed S.G.	
	Et Br	H—M_2—Br	15·25—M_2—27·00	1·438	1·450 15° P.	1·419 15° M
	Pr Br	H—M_3—Br	15·25—M_3—27·00	1·333	1·350 0° Pr.	∴ 1·333 15°
	But Br	H—M_4—Br	15·25—M_4—27·00	1·260	1·260 14° Dh.	
160	Am Br	H—M_5—Br	15·25—M_5—27·00	1·206	1·206 15·7° M	
	Hep Br	H—M_7—Br	15·25—M_7—27·00	1·132	1·133 16° Cs.	
	Ethyl I	H—M_2—I	15·25—M_2—32·75	1·930	1·931 15° M.	1·031 14° G.
	Prop I	H—M_3—I	15·25—M_3—32·75	1·748	1·748 14° Dh.	1·747 16° L
	Butyl I	H—M_4—I	15·25—M_4—32·75	1·619	1·617 20° B.	
	n-Pent I	H—M_5—I	15·25—M_5—32·75	1·522	1·517 20° Lb.	∴ 1·522 15°
165	Hexyl I	H—M_6—I	15·25—M_6—32·75	1·447	1·466 0° Db.	∴ 1·448 15°
	Hept I	H—M_7—I	15·25—M_7—32·75	1·387	1·401 0° Db.	∴ 1·383 15°
	Octyl I	H—M_8—I	15·25—M_8—32·75	1·338	1·338 16° Zi.	
	Nonyl I	H—M_9—I	15·25—M_9—32·75	1·297	1·287 16° Kr.	
	Decyl I	H—M_{10}—I	15·25—M_{10}—32·75	1·263	1·287 0° Kr.	1·260 16° Kr.
170	Et Amine	H—M_2—NH_2	15·25—M_2—16·42	0·698	0·696 8° W.	0·699 8° Va
	But amine	H—M_4—NH_2	15·25—M_4—16·42	0·75	0·7553 0° Lb.	
	Amyl amine	H—M_5—NH_2	15·25—M_5—16·42	0·765	0·772 0° Pl.	∴ 0·762 15°
	Hex amine	H—M_6—NH_2	15·25—M_6—16·42	0·776	0·768 17° Pe.	∴ 0·77 15°
175	Oct amine	H—M_8—NH_2	15·25—M_8—16·42	0·79	0·786 Sq	
	M-nitril	H—M_{13}—CN	15·25—M_{13}—23·96	0·827	0·828 19° Kr.	0·824 25° Kr.
	Pl-nitril	H—M_{15}—CN	15·25—M_{15}—23·96	0·830	0·822 31° Kr.	0·776 99° Kr ∴ 0·830 15°
	Ste-nitril	H—M_{17}—CN	15·25—M_{17}—23·96	0·833	0·818 41° Kr	0·779 99° Kr ∴ 0·835 15°
	Me triaz	H—M—N_3	15·25—M—32·63	0·89	0·896 8° Va.	∴ 0·891 15°
180	Et nitrate	H—M_2—NO_3	15·25—M_2—34·27	1·105	1·104 25° K.	1·113 15° Ko
	Pr nitrate	H—M_3—NO_3	15·25—M_3—34·27	1·063	1·063 15° Va.	
	Et mercap	H—M_2—SH	15·25—M_2—25·48	0·843	0·842 15° Ze.	0·830 20° N
	But mercap	H—M_4—SH	15·25—M_4—25·48	0·846	0·843 16° Gr.	0·858 0° Gr
	Am mercap	H—M_5—SH	15·25—M_5—25·48	0·847	0·840 17° Ko.	0·848 13° BH
185	Et acetate	H—M_2—CO_2CH_3	15·25—M_2—49·71	0·900	0·901 20° B.	0·898 15° M
	Pr acetate	H—M_3—CO_2CH_3	15·25—M_3—49·71	0·893	0·899 15° L.	0·885 20° B
	Bu acetate	H—M_4—CO_2CH_3	15·25—M_4—49·71	0·888	0·882 20° Lb.	0·900 0° Lb
	n-Am acet	H—M_5—CO_2CH_3	15·25—M_5—49·71	0·884	0·896 0° Lb.	∴ 0·884 15°
	n-Hex acet	H—M_6—CO_2CH_3	15·25—M_6—49·71	0·881	0·890 0° Ga.	∴ 0·88 15°
190	n-Hep acet	H—M_7—CO_2CH_3	15·25—M_7—49·71	0·878	0·874 16° Cs.	0·889 0° Ga
	n-Oct acet	H—M_8—CO_2CH_3	15·25—M_8—49·71	0·876	0·885 0° Ga.	∴ 0·875 15°
	Me pelarg	H—M_8—CO_2CH_3	15·25—M_8—49·71	0·876	0·876 17° Zi.	
	Et propion	H—M_2—$CO_2C_2H_5$	15·25—M_2—66·13	0·893	0·894 17° L.	0·891 15° Ir.
	Et butyr	H—M_3—$CO_2C_2H_5$	15·25—M_3—66·13	0·888	0·899 0° El.	∴ 0·888 15°
195	Pr propion	H—M_3—$CO_2C_2H_5$	15·25—M_3—66·13	0·888	0·888 13° L.	
	Et valerate	H—M_4—$CO_2C_2H_5$	15·25—M_4—66·13	0·884	0·894 0° Lb.	0·878 18° C
	Bu propion	H—M_4—$CO_2C_2H_5$	15·25—M_4—66·13	0·884	0·883 15° L.	
	Am propion	H—M_5—$CO_2C_2H_5$	15·25—M_5—66·13	0·881	0·888 0° El.	
	Et capro	H—M_5—$CO_2C_2H_5$	15·25—M_5—66·13	0·881	0·878 19° C.	∴ 0·881 15°
200	Et oenanth	H—M_6—$CO_2C_2H_5$	15·25—M_6—66·13	0·878	0·877 16·5° C.	∴ 878 15°
	Et capryl	H—M_7—$CO_2C_2H_5$	15·25—M_7—66·13	0·876	0·874 15° Fe.	0·878 17° C
	n-Hep prop	H—M_7—$CO_2C_2H_5$	15·25—M_7—66·13	0·876	0·885 0° Ga.	∴ 0·874 15°

ABBREVIATIONS.—Ab, Ahrers; Ar, Arnheim; Bb, Barbier; BH, Biochem Handlexicon; Bl, Beilstein; Cs, Cross; Cu, Claus; Db, Dobriner; El, Elsasser; Fe, Fehling; Fi, Fischer; Gr, Grabowski; Ht, Holtmeyer; Ir, Israel; Ja, Jacobsen; Kg, Kruger; Kn, Korner; Kt, Kraut; Lf, Lefebvre; Lc, Lachowicz; Lm, Lemoine; LB, Le Bas; N, Nasini; Na, Naquet; No, Nolting; Pe, Pelouze; Pp, Philip; Pr, Pierre; Ps, Petersen; Py, Parry; Rd, Rudorff; Rm, Ramsay; Rn, Renard; Scm, Schramm; Sd, Stadeler; Se, Schwanert; Sf, Senfl; Sp, Schepper; Sq, Squire; Sz, Schweinitz; Ta, Tawildarow; Vi, Vincent; Wa, Warren; Wk, Walker; Ze, Zeise; Zi, Zincke.

	Name & Chem. formula.		Vols. of parts.	Theor. S.G.	Observed S.G.	
	Et pelarg	$H—M_8—CO_2C_2H_5$	$15·25—M_8—66·13$	0·874	0·873 15° De.	
	n-Oc prop	$H—M_8—CO_2C_2H_5$	$15·25—M_8—66·13$	0·874	0·883 0° Ga.	∴ 0·873 15°
205	Et laurate	$H—M_{11}—CO_2C_2H_5$	$15·25—M_{11}—66·13$	0·870	0·867 19° De.	∴ 0·870 15°
	n-Hep butyr	$H—M_7—CO_2C_3H_7$	$15·25—M_7—82·55$	0·874	0·883 0° Ga.	∴ 0·872 15°
	Pr butyr	$H—M_2—CO_2C_3H_7$	$15·25—M_3—82·55$	0·884	0·893 0° El.	0·879 15° L.
	Pr capro	$H—M_3—CO_2C_5H_{11}$	$15·25—M_{11}—115·39$	0·878	0·884 0° Ga.	∴ 0·873 15°
	Butyl alc	$H—M_4—OH$	$15·25—M_4—10·21$	0·812	0·811 15° L.	0·810 20° B
210	Amyl alc	$H—M_5—HO$	$15·25—M_5—10·21$	0·818	0·818 15° C.	0·818 14° De
	Hexyl alc	$H—M_6—HO$	$15·25—M_6—10·21$	0·823	0·820 20° Lb.	∴ 0·823 15°
	Heptyl alc	$H—M_7—HO$	$15·25—M_7—10·21$	0·826	0·819 23° Sd.	0·830 16° Cs
	Octyl alc	$H—M_8—HO$	$15·25—M_8—10·21$	0·829	0·830 16° Zi.	0·837 0° Z
	Nonyl alc	$H—M_9—HO$	$15·25—M_9—10·21$	0·831	0·835 10° Kr.	0·828 20° Kr
215	Decyl alc	$H—M_{10}—HO$	$15·25—M_{10}—10·21$	0·833	0·830 20° Kr.	∴ 0·833 15°
	Dod ec alc	$H—M_{12}—HO$	$15·25—M_{12}—10·21$	0·836	0·831 24° Kr.	∴ 0·836 15°
	n-Alcohol	$H—M_{14}—HO$	$15·25—M_{14}—10·21$	0·838	0·824 38° Kr.	0·815 50° Kr
						∴ 0·838 15°
	n-Alcohol	$H—M_{16}—HO$	$15·25—M_{16}—10·21$	0·840	0·810 60° Kr.	0·784 99° Kr
						∴ 0·840 15°
	n-Alcohol	$H—M_{18}—HO$	$15·25—M_{18}—10·21$	0·841	0·812 59° Kr.	0·785 99° Kr
						∴ 0·841 15°
220	Myris acid	$H—M_{13}—CO_2H$	$15·25—M_{13}—23·80$	0·903	0·862 54° Va.	∴ 0·90 15°
	Palm acid	$H—M_{15}—CO_2H$	$15·25—M_{15}—23·80$	0·897	0·846 76° Va.	∴ 0·89 15°
	Stear acid	$H—M_{17}—CO_2H$	$15·25—M_{17}—23·80$	0·893	0·852 69° Sh.	0·843 80° Va
						∴ 0·899 15°
	Cerot acid	$H—M_{26}—CO_2H$	$15·25—M_{26}—23·80$	0·881	0·836 70° Va.	∴ 0·88 15°
	Heptidene	$H—M_5—C_2H$	$15·25—M_5—31·25$	0·746	0·746 20° B.	
225	Conylene	$H—M_6—C_2H$	$15·25—M_6—31·25$	0·76	0·76 CK.	0·770 0° Va

Fourth Deduction.—The experimental facts concerning the following 24 molecules demonstrate that another relative volume of H is 12·22 at 15° C., for, whether Cl, Br, I, NH_2, CN, N_3, NO_3, SH, CO_2CH_3, $CO_2C_2H_5$, $CO_2C_3H_7$, OH(10·21), C_2H or CO_2H be displaced by H in such molecules as those numbered 150—225, the relative volume of the H-atom is always the same.

The Paraffins. M stands for methylene (16·42).

	Formula.		Vols. of parts.	Theor S.G.	Observed S.G.		
	$H—M_3—H$	... ...	$15·25—M_8—12·22$	0·573	0·613 −25° Lf.		∴ 0·58 15°
	$H—M_4—H$	... ...	$15·25—M_4—12·22$	0·623	0·624 −1° Lf.		
	$H—M_6—H$	... ...	$15·25—M_6—12·22$	0·683	0·678 15° Sc.	0·698 14° Lc.	
	$H—M_7—H$	... ...	$15·25—M_7—12·22$	0·702	0·702 14° Lc.		
230	$H—M_8—H$	... ...	$15·25—M_8—12·22$	0·718	0·719 17° Sc.	0·716 15° T.	
	$H—M_9—H$	... ...	$15·25—M_9—12·22$	0·730	0·731 16° Lm.	0·733 0° LB.	
	$H—M_{10}—H$	... ...	$15·25—M_{10}—12·22$	0·741	0·732 20° Lc.	0·753 16° Lm.	
	$H—M_{11}—H$	... ...	$15·25—M_{11}—12·22$	0·750	0·745 15° Kr.	0·758 20° Va.	
	$H—M_{12}—H$	... ...	$15·25—M_{12}—12·22$	0·757	0·755 15° Kr.	0·768 20° Va.	
235	$H—M_{13}—H$	... ...	$15·25—M_{13}—12·22$	0·764	0·761 15° Kr.		
	$H—M_{14}—H$	... ...	$15·25—M_{14}—12·22$	0·769	0·768 15° Kr.	0·775 5° Kr.	
	$H—M_{15}—H$	... ...	$15·25—M_{15}—12·22$	0·774	0·772 15° Kr.		
	$H—M_{16}—H$	... ...	$15·25—M_{16}—12·22$	0·779	0·775 18° Kr.		
	$H—M_{17}—H$	... ...	$15·25—M_{17}—12·22$	0·783	0·776 22° Kr.	0·771 30° Kr.	∴ 0·782 15°
240	$H—M_{18}—H$	... ...	$15·25—M_{18}—12·22$	0·786	0·777 28° Kr.		∴ 0·786 15°
	$H—M_{19}—H$	... ...	$15·25—M_{19}—12·22$	0·789	0·777 32° Kr.	0·772 40° Kr.	∴ 0·789 15°
	$H—M_{20}—H$	... ...	$15·25—M_{20}—12·22$	0·792	0·778 37° Kr.	0·749 80° Kr.	∴ 0·792 15°
	$H—M_{21}—H$	... ...	$15·25—M_{21}—12·22$	0·795	0·778 40° Kr.	0·740 99° Kr.	∴ 0·795 15°
	$H—M_{22}—H$	... ...	$15·25—M_{22}—12·22$	0·798	0·778 44° Kr.	0·742 99° Kr.	∴ 0·799 15°
245	$H—M_{23}—H$	... ...	$15·25—M_{23}—12·22$	0·800	0·778 47° Kr.	0·746 99° Kr.	∴ 0·800 15°
	$H—M_{24}—H$	... ...	$15·25—M_{24}—12·22$	0·802	0·779 51° Kr.	0·748 99° Kr.	∴ 0·802 15°
	$H—M_{27}—H$	... ...	$15·25—M_{27}—12·22$	0·807	0·780 59° Kr.	0·754 99° Kr.	∴ 0·809 15°
	$H—M_{31}—H$	... ...	$15·25—M_{31}—12·22$	0·813	0·781 68° Kr.	0·762 99° Kr.	∴ 0·817 15°
	$H—M_{32}—H$	... ...	$15·25—M_{32}—12·22$	0·814	0·781 70° Kr.		∴ 0·817 15°

Fifth Deduction.—Methyl has the volume 31·67 (=16·42+15·25) at one end of a carbon chain, and the volume 28·64 (=16·42+12·22) at the other end.

Sixth Deduction.—When an atom of hydrogen, whose volume is 15·25, is displaced by CH_3, the volume of the latter is 16·42+15·25; and when an atom of H, whose volume is 12·22, is displaced by CH_3, the volume of the latter is 16·42+12·22.

Seventh Deduction.—The two valencies of carbon so far concerned are distinguished from one another by the fact that H has the volume 15·25 in one position, and 12·22 in the other. (The former will be called the "first position," and the latter the "second position.").

As said before, it is evident that perfect regularity in the relative volumes of molecules exists at the temperature of 15° C.; so that it is quite plain that Kopp's very inaccurate conclusions with regard to the relative volumes of molecules at their various boiling points have misled scientists for more than half-a-century.

It is necessary to remember that it is impossible to find exact regularity in 250 molecules, if it is not really there to be discovered.

There is no other explanation possible of the above results than that an atom of hydrogen occupies a volume of 15·25 in the first position of the *carbon* atom, and of 12·22 in the second position.

If chemists like to consider that these two volumes include co-volumes, they must then admit that these atoms are differentiated by their co-volumes.

The exact volumes of the two H-atoms in methylene (CH_2) will be shown later, and *it will* then be seen that the four valencies of carbon can easily be differentiated. They will also be *differentiated in other ways.*

The doctrine that the four valencies of carbon are indistinguishable from one another is the greatest stumbling-block that has ever been placed in the way of scientists, and accounts for the *apparently inextricable* confusion in the higher regions of chemistry.

THE BEHAVIOUR OF SUBSTANCES NEAR THE ABSOLUTE ZERO.

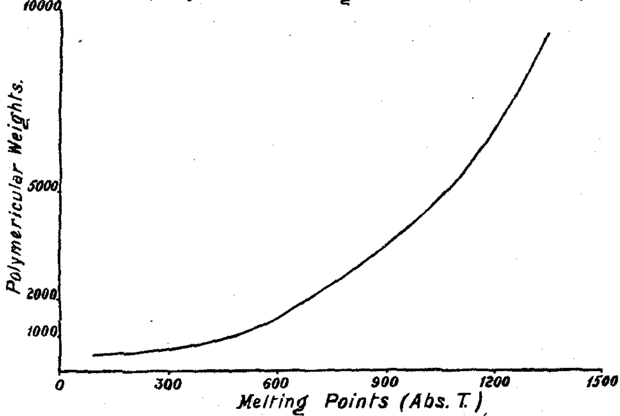
By WILLIAM R. FIELDING, M.A., M.Sc., Vict.
Senior Science Master at King Edward VII School, Lytham.

THE present paper is an application of the author's previous results (described in CHEMICAL NEWS, Vol. cxx., No. 3136; Vol. cxxii., No. 3170) to *several substances in the neighbourhood of the* absolute zero.

Recent work by Kamerlingh Omnes, and Keesom (1915) has provided us with the following specific heats for lead at very low temperatures.

T	S
46° A.	0·0242
22° A.	0·0143
14° A.	0·0075

ABSOLUTE ATOMIC WEIGHTS.
(Polymericular Weights at the absolute zero.)



This matter will be kept absolutely free from conjecture, and every deduction which is demonstrated will be supported by overwhelming evidence obtained from the experimental numerical data of other men.

When the same individual both performs the experiments and also reasons upon the results, there is a danger that his experimental figures may be unconsciously influenced by his preconceived ideas.

(To be continued).

IN a paper in the *Philosophical Magazine* for May last, Mr. A. H. Compton describes a new method for the calculation of short wave-lengths by which he has been able to measure the wave-length of Hard Gamma Rays, the value determined for rays that have passed through 8 mm. of lead is from 0·025 to 0·030 Angström units.

There are three ways of estimating specific heats between 14° and 0° A.

(1) From the specific heats curve the specific heat of lead appears to be zero at about 6° A.

(2) If we plot the above specific heats against absolute temperatures, and produce the curve to 0° A., *the following specific heats are obtained* :—

T	S
10° A.	0·0053
5° A.	0·0027
4° A.	0·0022
2° A.	0·0012
1° A.	0·00005

(3) We can apply Debige's Law (atomic heat $= kT^3$) below 14° A., and get the following values :—

TABLE I. (Lead).

T	Melticular Weight	R.	S_T.	Specific Heats. I	t	II	p	III.	p
0							18 ?		3-4000
2	1	0·0048	0·0149			0·0012	12·4	0·0000218	68
4	3	0·0144	0·0224			0·0022	10·2	0·0001747	12
5	4	0·0192	0·0238			0·0027	8·8	0·00034	7
6				0·0	7·0				
10	8	0·0384	0·0230	0·0053	4·5	0·0053	4·5	0·00273	8·7
*14	12	0·058	0·0257	0·0075	3·43	0·0075	3·43	0·0075	3·4
*22	21	0·101	0·0285	0·0143	2	0·0143	2	0·0143	2·0
*46	51	0·245	0·0331	0·0242	1·37	0·0242	1·37	0·0242	1·3
*92	117	0·562	0·0380	0·0285	1·33	0·0285	1·33	0·0285	1·3

*Specific heats actually observed.

TABLE II. (Water).

T	Melticular Weight.	R.	S_T.	Specific Heats. I	φ	II	p	III	p
0					30 ?	0·0	140 ?		?
2	1	0·166	0·516			0·005	103	0·000008	64500
4	3	0·5	0·78			0·01	78	0·000063	12400
5	4	0·66	0·82			0·013	63	0·000125	6550
10	8	1·33	0·827			0·03	27·6	0·001	827
20	18·5	3·08	0·958			0·058	16·52	0·0077	124
*53	60	10	1·232	0·146	8·44	0·146	8·44	0·146	8·4
*140	214	35·6	1·510	0·285	5·30	0·285	5·30	0·285	5·3
*225	330	55	1·529	0·463	3·30	0·463	3·30	0·463	3·3
*273	414	69	1·556	0·504	3·08	0·504	3·08	0·504	3·08

TABLE III. (Copper).

T.	Melticular Weight	R	S_T	Specific Heats. I	p	II	p	III	p
0							1200 ?		
2	1	0·016	0·05			0·00006	833	0·000002	25000
5	3·8	0·06	0·07466			0·00015	500	0·00003	2486
10	8	0·127	0·079			0·0004	198	0·00024	330
12				0·0	150 ?				
*15	13·5	0·214	0·087	0·0008	109	0·0008	109	0·0008	109
*22	20·5	0·325	0·094	0·0022	42·7	0·0022	42·7	0·0022	42·7
*330	518	8·2	0·1545	0·0933	1·67	0·0933	1·67	0·0933	1·67

T	S
10° A.	0·00273
5° A.	0·00034
4° A.	0·0001747
2° A.	0·0000218
1° A.	0·0000027

The values of p (degree of polymerisation) calculated from each series of specific heats are widely different (see Table I.).

The serious objection to the third set of results is their magnitude, for between 10—0° A. each lead polymer of (Pb_{8+}) is transformed into a huge one of (Pb_{3-4000})—a miracle of molecular activity! The second result, where $p=18$, appears to be not *unlikely*.

The results for water are also obtained in the same three ways (see Table II.).

The third set of values seem beyond the reach even of the imagination, and the second set give water a polymericular weight of $140 \times 18 = 2520$ at the absolute zero. The behaviour of other elements, referred to later, makes $p=30$, a more probable value.

The values of p for copper are given in Table III.

The results for carbon (diamond) are obtained in the same way, but are very much larger in magnitude. Thus, the most likely polymericular weights are:—

	I	II
Water (m p. 273°)	540	2520
Lead (m.p. 600°)	1456	3744
Copper (m.p. 1350°) ...	9450	75600

The former values, based on experimental records to almost the absolute zero, are tentatively accepted as correct.

If we plot these values against melting points we obtain (by interpolation) possible values for p for other elements at the absolute zero.

The curve (Fig. I.) is constructed from the following data:—

T	p	Absolute Molecular Weights. (Polymericular Weights)
Copper (1350°) ...	150	9450
Lead (600°)	7	1456
Water (273°)	30	540

The curve can be extended in either direction by finding p for other elements of higher or lower melting points.

p has a periodic value as will be seen from the following groups.

GROUP I.

M.P.	Element		Polymericular Weight.	p	
459	Li		900	128	
371	Na		800	35	
335	K		640	16+	
1356		Cu	9450		150
311	Rb		600	7+	
1233		Ag	7200		66·6
299	Cs		560	4·2	
—		—	—		—
—	—		—	—	
1336		Au	9000		45

GROUP V.

M.P.	Element		Polymericular Weight.*	p	
63		N	450?	32+	
317		P	600	19+	
	V				
1123		As	5600		76+
	Nb				
903		Sb	3500		30
	Ps				
		—			
	Ta				
504		Bi	1180		5·7

The transitional elements, arsenic, antimony, and bismuth, thus form a separate sub-group.

GROUP VII.

M.P.	Element	Polymericular Weight.	p
50	F	450	24—
171	Cl	500	14
266	Br	530	6·6
387	I	800	6·3

p for mercury will only be about 2+ at the absolute zero, whereas argon will be about Ar_{16}, and helium still more highly polymerised.

Benzene will be about $(C_6H_6)_7$, naphthalene $(C_{10}H_8)_{5-6}$, and anthracene $(C_{14}H_{10})_{5\cdot 6}$. Acetic acid may be $(CH_3COOH)_{10}$.

Notes.

(1) If the values of p had been calculated from *Debige's specific heats*, they would all have been enormously higher.

(2) Certain discrepancies, *e.g.*, the low value for naphthalene, would disappear on plotting polymericular weights against absolute boiling-points.

(3) The curve would be still more reliable if it were based on the behaviour of, say, half-a-dozen substances.

(4) The numbers of atoms in the benzene, naphthalene, and anthracene polymers at 0° A are about 84, 100, and 132 respectively.

PRINCIPLES GOVERNING THE GRANT OF MINERAL CONCESSIONS IN INDIA.

By THE HON. SIR THOMAS H. HOLLAND, K.C.S.I., K.C.I.E., D.Sc., LL.D., F.R.S.

IT is the business of a mining company to make as much profit as possible out of a mineral deposit during the period of its mining lease: it is the business of Government to safeguard a national asset of vital importance which cannot be replaced or renewed. But it is better for a country that its mineral deposits should be worked than that they should be left lying idle in the ground. The problem before Government, therefore, or before any large owner of mineral rights, is to frame conditions for the grant of mineral concessions which will ensure a fair return to the State, without undue waste, and yet be liberal enough to attract the investor in mines.

The mineral policy of a Government is thus the choice of a judicious mean between extravagance and conservatism. And as the values of minerals vary with the industrial development of a country and that of the countries with which it is in trade communication, this judicous mean will gradually shift its position between the two extremes. Yet, to attract the investor, stability of policy is also necessary; and thus, whilst the rules for the grant of mineral concessions should be modified from time to time to safeguard the interests of theState, frequent changes which will unsettle private enterprise must be avoided.

In a country as large as India, a mineral that is workable in one province may be unworkable in another, where fuel may be scarce, means of transport undeveloped, or markets unobtainable. Thus, some local variations in the conditions for the grant of mineral concessions may be necessary; yet, because the development of one mineral is often not possible without the simultaneous development of another, the rules should prescribe limiting conditions sufficiently narrow to ensure *a judicious degree of uniformity* over wide areas.

The whole problem of framing and workng a mineral policy for all India is, thus, the choice of a judicious mean in all things—rents, royalties, terms, areas, and conditions of tenure.

As justification for *conservatism*, the Government has to realise:—

(1) That mineral products are essential for the maintenance of modern civilised activities; when they approach exhauston, the country will be absolutely dependent on foreign sources.

(2) That a mineral once worked is lost to the country for ever: nothing can renew a mineral deposit.

(3) That the miner works only those parts of the deposit that are commercially profitable at the time, often leaving behind far larger quantities of the same mineral in a condition even less fitted than before for profitable exploitation; a mineral deposit which is not worth working to-day may become of great value when processes are improved, or when, through industrial development, local markets become changed.

(4) That, when a company obtains a mining lease, the State, as the owner of mineral rights, goes into effective partnership with the company. The State contributes the mineral deposit as its share of the capital, whilst the mining company provides the working capital. At the end of the lease, when the mineral deposit has been worked out, the State's share of the capital has disappeared, whilst the mining company has secured the profits, and, if successful, has redeemed the whole of its investment. A mineral deposit, therefore, becomes a wasting State asset from the date on which it is leased to an active mining company, and the only compensation that the State obtains for the exhaustion of its mineral deposits

is (*a*) the royalty paid, and (*b*) the money spent in local work. As the royalty rates now prescribed in India are rarely more than one-fortieth of the actual mineral values, the return to the State under present conditions is less than the potential value of the mineral; for the royalty is paid on the mineral actually sold by the miner, and not on that left behind through his bad working, or because, at the time, the deposits are locally too poor to be worth exploitation.

The whole process of mineral exploitation is, thus, essentially wasteful: large quantities of rich mineral are left behind for various reasons; larger quantities are damaged by disturbance of the ground in mining; a large percentage of each mineral is lost during the process of dressing for the market or the smelter; and, in the case of ores, a serious percentage is lost in the process of smelting. Finally, the refined product is used in the Arts, and thus scattered too widely to make it payable to collect again into workable form. A workable mineral deposit is the product of natural processes of concentration which have been going on for geological ages; but the results of these slow processes are undone in a few years by the miner, whose every mistake is irreparable. It has been well said that, whilst the results of bad farming can be recovered and the fertility of damaged land can be renewed, there are no fertilisers for worked-out mines.

As justification, on the other hand, for *liberality*, it is necessary to remember:—

(1) That most mining enterprises are highly speculative, and the investor wants the encouragement of generous terms before he will risk his capital in an unproved country.

(2) That most of the capital is sunk in an irrecoverable form: the miner cannot sell underground galleries and shafts in the open market; he must, therefore, hope to recover his capital outlay from profits and that in a relatively short period.

(3) That, unless a miner can now and then reap the benefit of an occasional windfall, he will not be justified in writing off the losses due to the large number of unlucky ventures which seem to be the constant accompaniments of mining enterprises.

(4) That mineral products are essential to most industries, and it is much better to use them even wastefully than to leave so much national capital lying idle.—*Journal of Indian Industries and Labour*, May, 1921.

THE June and July issue of the *Journal of the Franklin Institute* contains a paper that was presented at the Annual Meeting of the Institute held in January, by John E. Lieb, M.E., detailing the remarkable discoveries and experiments of Leonardo da Vinci in engineering. The article is very fully illustrated. The multiplicity of devices is remarkable, and include a cyclometer, a pedometer, a dynamometer, a spring-driven automobile, a friction-driven fire escape, and wings for a flying machine. Numerous extracts from his diary show that he lived much in advance of his time, and many of his devices are of present-day interest.

FUEL PROBLEMS OF THE FUTURE.*

By SIR GEORGE T. BEILBY, F.R.S.

TURNING now to oil, the other great natural source of fuel, we find that the world's output for 1920 was about 97 million tons, of which the

	Per cent.
United States produced ...	64·8
Mexico	23·3
Russia	3·5
Dutch East Indies	2·5
India	1·2
Roumania	1·1
Persia	1·0
Countries producing less than 5 per cent	2·6
	100·0

The oil output therefore amounted to 7 per cent of the fuel output of the world, reckoned in tons. If reckoned in potential therms, the figure would be raised to 10 per cent.

As the United States has extensive oil interests in Mexico, it may be taken that last year she controlled 75 to 80 per cent of the total output of the world. It is therefore significant that, in official quarters, grave anxiety has been expressed as to the probable exhaustion of these resources in view of the rapid development in the use of motor spirit for road transport and of fuel oil for transport by sea.

While we are justified in discounting to some extent the elements of popular panic which have been obvious in much that has appeared in technical journals, as well as in the daily Press, the fact remains that, but for the rapid development of production in Mexico, and the extensive interests of the United States in this production, the actual danger of shortage in America would have already become more acute.

The following extract from a statement by Mr. J. O. Lewis, Chief Petroleum Technologist to the United States Bureau of Mines, expresses so very clearly the American view of the oil problem of the future that I cannot do better than quote it *in extenso*. No mere paraphrase would convey the same impression of reality.

"The United States Geological Survey during the last ten years has made several estimates of the quantity of oil left in our old fields. The most recent estimate—that of David White—indicates that about 40 per cent of the oil had been brought to the surface, and that the 60 per cent remaining underground, if recovery as needed were possible, would last barely 20 years at the present rate of consumption. As the period in which an oil field can be made to yield its oil is not wholly within the control of man, the domestic production will undoubtedly be spread over a much longer period than that estimated; but, on the other hand, the peak of production will be passed long before 20 years, and thereafter production will be at a declining rate. Of course, such estimates are by no means infallible, as many obscure factors are involved. However, this statement represents the opinion of the agency best qualified to make such an estimate, and is indicative of a condition which, were there no other solution to the problem, would be highly unsatisfactory,

*Delivered in the theatre of the Institution of Civil Engineers, London. Inserted by favour of the *Gas Journal*, June 29, 1921.

and would be viewed by the automotive industry with the greatest concern. For, even were the estimate unduly pessimistic, and the actual reserve twice that shown, the condition would still be unsatisfactory.

The preceding statement refers only to the oil from oil wells in the United States. Fortunately there are enormous undeveloped resources in the rest of the world. The petroleum resources of this country have been developed and depleted in a ratio far beyond that of other countries, so that although we are producing to-day two-thirds of the world's production, the opportunities elsewhere for increasing production are much greater than in the United States. Geologists and those well informed on foreign resources believe that in all probability the world contains enormous reserves of oil that can be obtained upon demand. Although to obtain oil from these reserves may not be as satisfactory as to obtain it within the confines of the United States, the outlook tends to assure the future of the internal combustion engine.

Fortunately, oil may be obtained from other sources than oil fields. In various parts of the United States, particularly in Colorado, Wyoming, and Utah, are enormous bodies of oil shales from which oil may be obtained by destructive distillation, as benzole is obtained from coal. The United States Geological Survey has estimated the quantity of oil locked up in the richer shales of the three States mentioned as perhaps ten times the amount of the oil reserve in the oil-fields. In Scotland, the retorting of oil from oil shales has been on a commercial basis for more than 50 years, and antedates the oil industry in the United States. Commercial and semi-commercial experiments are being made in order to determine whether the oil shales of the Western States can be mined and retorted profitably in competition with petroleum from oil fields. This problem has not yet been solved; but these shales constitute a latent reserve that protects the future needs of the country for motor fuel as far as these needs can be foreseen. However, oil cannot be obtained from the shales on a large scale without heavy investments; and the development of the industry must be spread over many years. Also, when that time comes, the consumer will probably have to pay more for his gasoline.

As regards the question of substitutes, if prices of petroleum products advance sufficiently, alcohol may become one of the motor fuels of the future. The efficient use of alcohol requires, however, certain modifications in the present design of the mobile internal combustion motor. Moreover, large quantities of lubricants are required, in addition to motor fuel. Hence it seems desirable to continue to depend on crude oil as a principal source as long as possible, especially as crude oil is the only known satisfactory raw material yielding both motor fuel and lubricants.

Briefly, motor fuels may be obtained from four possible sources: (1) Petroleum from our own wells; (2) petroleum from wells in foreign countries; (3) oil from our oil s[illegible] line substitutes. As to the first, [illegible] but not immediate concern. As to [illegible] believed that there remain enorm[illegible] serves outside the United States. [illegible] there are known deposits of oil shales which, in three States alone, promise to yield many times more oil than will be ever be recovered from our oil wells. As to the fourth, it is probable that eventually alcohol could meet our needs should gasoline fail. Thus, while there is concern over our own domestic supplies of petroleum from oil wells, there is no concern as to the ultimate supply. There may be critical periods when one source fails, and before another has been developed; also it is not unlikely that when our own wells fail, and we have to fall back on oil from foreign coutries or oil shales, we shall have to pay more for our motor fuel.

In view of this reference to alcohol as a probable substitute for motor spirit, it may be well here to refer to the action of the British Government in this connection.

In view of the national importance of the subject, Mr. Walter Long appointed a Committee in October, 1918, to report upon:

(1) The various available sources of supply of alcohol, the methods of manufacture, and the cost of the product.

(2) The suitability of alcohol, either alone in admixture with solid, liquid, or gaseous combustible substances, for use in internal combustion engines, and the modifications of the existing types of such engines which may be necessary to the attainment of efficiency.

(3) The question of denaturing the alcohol, and the alterations to be made in the present Excise Bill.

The Committee obtained much useful information of a preliminary nature; and in June, 1919, they issued a report which was presented to Parliament on June 30.

One of the recommendations of the report was: "That an organisation should be established by the Government to initiate and supervise experimental and practical development work, at home and overseas, on the production and utilisation of power alcohol, and to report from time to time for public information on all scientific, technical, and economic problems connected therewith."

This report was in due course considered by the Committee of Council for Scientific and Industrial Research, who recommended the Fuel Research Board to continue the investigation of the problems.

As a first step in these inquiries, the Fuel Research Board recommended the appointment of Sir Frederick Nathan as Power Alcohol Investigation Officer. This appointment was confirmed by the Lord President on December 17, 1919. Since his appointment, Sir Frederic Nathan has devoted his whole time to these inquiries, and has been in close touch with the Government Departments interested in the questions involved.

In July, 1920, an Interim Memorandum on "Fuel for Motor Transport" was published by the Fuel Research Board, in which the situation at that date was summed up as follows:—

"The main sources of alcohol are vegetable materials containing starch or sugar; and practically all the alcohol for potable and industrial [illegible] made from grains or molasses. [illegible] large quantities of alcohol were [illegible]ly from potatoes, specially grown [illegible] so be produced from the ferment-

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	Quantities. Required for 250 Million Gallons Tons.	Quantities. United Kingdom Production, 1919. Tons.	Acreage.* Required for 250 Million Gallons.†	Acreage.* Under Crop in 1919.	Raw Material. Average Price per Ton, 1919, £	s.	d.	Cost per Gallon of Alcohol. s.	d.
Grain (barley)	4,170,000	1,288,035	5,593,293	1,870,087	21	4	0	7	0
Potatoes	12,500,000	6,312,000	2,118,644	1,218,774	8	10	6	8	6
Mangolds	25,000,000	7,769,000	1,282,513	471,759	1	10	0	3	0

* Total arable acreage of the United Kingdom—about 21 million acres.
† Based on ten years' average yields.

able sugars formed by the hydrolysis of wood cellulose, and synthetically from calcium carbide, or from the ethylene contained in coke-oven and coal gas. The quantity of waste wood in this country for alcohol production is, however, negligible. Calcium carbide is impossible, as it cannot be produced in quantity without cheap power; and the recovery of ethylene from coke-oven and coal gas, and its conversion into alcohol, are still in the experimental stage. At the present time, therefore, none of these three sources of supply is of appreciable commercial importance in this country.

The vegetable materials growable in this country from which alcohol could be made are grain (barley), potatoes, and mangolds; and the following figures relating to the production of 250 million gallons of 95 per cent alcohol are interesting (see Table above).

These figures are not encouraging; and generally it may be stated that the production of alcohol in any considerable quantities from vegetable materials grown in the United Kingdom is not economically possible owing to: (1) Insufficient acreage; (2) the high cost of cultivation and harvesting; (3) the high cost of manufacture; and (4) the fact that the most suitable raw materials are also important foodstuffs. There is for these reasons no prospect of replacing any considerable *quantity of petrol by home-produced alcohol.* Moreover, it is unthinkable that land, for even a fraction of the quantity of the raw materials in the above Table, could be used for such a purpose, when in the matter of food production, a week-end supply only is assured from our own land.

(To be continued).

CHEMICAL NOTICES FROM FOREIGN SOURCES.

Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences. Vol. clxxiii., No. 4.

"Critical Potentials and Band Spectra of Nitrogen."—By MM. Léon and Eugène Bloch.

"The Conductivity of a Solution of Eupram-monium Citrate compared with that of Copper Sulphate"—By MM. F. Beaulard de Lenaizin and L. Maury.

"Flocculation of Colloidal Arsenic Sulphide Influence of the Dilution of the Electrolyte and of the Quantity of the Electrolyte."—By MM. A Boutaric and M. Vuillaume.

"Compounds of the Halogen Derivatives of Mercury and Thallium."—By MM. J. Barlot and Penot.

"Sulphonations in Presence of Iodine."—By M. V. Auger and Mddle. M. Vary.

NOTES.

Institute of Metals.—The following is the Programme of the more important arrangements at the Autumn Meeting, Birmingham, September 21 to 23, 1921.

Tuesday, September 20.—The Office of the Hon. Local Secretary (Mr. G. W. Mullins, M.B.E.), will be open at the Municipal Technical School, Suffolk Street, Birmingham, for the issue of tickets, badges, &c., and for general information.

Wednesday, September 21.—General Meeting of Members in the Examination Hall, Municipal Technical School, Suffolk Street, by kind permission of Dr. W. E. Sumpner, Principal. The Lord Mayor of Birmingham, Alderman William A. Cadbury, will open the Meeting with a brief address of welcome. Papers will be presented and discussed. Members assemble at the Grosvenor Rooms, Grand Hotel, Colmore Row, for Luncheon, by kind invitation of the Metal Trades' Association, viz., Brass and Copper Tube, Brass Wire, Brass-founders Employers', Brazed Brass Tube, British Aluminium Hollowware Manufacturers', Cold Rolled Brass and Copper, and Nickel Silver Associations. Visit to the University. Reception by the Vice-Chancellor of the University (Sir Gilbert Barling, Bart., C.B., C.B.E.) in the Great Hall; Address by the Principal (C. Grant Robertson, Esq., C.V.O., M.A.). Civic Reception by the Lord Mayor (Alderman W. A. Cadbury) in the City Art Gallery.

Thursday, September 22.—General Meeting of Members. Papers will be presented and discussed as time permits. Members meet at tram termini or railway stations (as per Local Reception Committee's later programme) for visits to works. Reception for Garden Party at the Botanical Gardens, Edgbaston.

Friday, September 23.—Motor Excursion to Kenilworth, Warwick, and Stratford.

In view of an expected considerable accession of new members in connection with the Birmingham Meeting, a Special Council Meeting is being held in London on September 7, for the purpose of considering Applications for Membership. All applicants for membership whose forms are in the Secretary's hands before noon on September 7 will be entitled to take part in the proceedings in connection with the Birmingham Meeting. Members

are asked by the Council to be good enough to convey this information to any of their friends who may be eligible for membership of the Institute, or send the addresses of such friends to the Secretary. The new List of Members is available upon request being made. A large number of papers are promised, and we hope to publish abstracts as soon as they have been read. Visits have been arranged to the following works: Alldays & Onions, Small Heath; W. & T. Avery, Ltd., Soho Works; Belliss & Morcom, Ltd., Ladywood; Birmingham Small Arms Co. Ltd., Small Heath; Cadbury Bros., Bournville; Earle, Bourne & Co., Ltd., Heath Street South; Elkington & Co., Ltd., Newhall Street; Elliott's Metal Co. Ltd., Selly Oak; Allen Everitt & Sons, Ltd., Smethwick; Kynoch, Ltd., Witton; Metropolitan Carriage, Wagon and Finance Co. Ltd., Saltley; Muntz's Metal Co. Ltd., French Walls; Tangye's, Ltd., Cornwall Works; H. Wiggin & Co. Ltd., Wiggin Street; Wolseley Motors, Ltd., Adderley Park.

CITY AND GUILDS OF LONDON INSTITUTE.—Mr. H. P. Philpot, B. Sc., A.M.Inst.C.E., Assistant Professor at University College, has been appointed to the Professorship of Civil and Mechanical Engineering at the Finsbury Technical College; and Mr. A. J. Hale, B.Sc., F.I.C., Chief Assistant in the Department of Applied Chemistry to the Professorship in that Department. The entrance examination of the College will be held on Tuesday, September 20.

WE learn from the *Board of Trade Journal* that a notice has been issued by the East Prussian State Railways advising precautions against pilferage. It is stated that binding packing cases with band iron is valueless unless special precautions are taken, and it is advised that cases should be first nailed together and then bound with iron; minute instructions are given as to how the iron should be nailed on to prevent theft.

TREATMENT OF CRUDE POTASSIUM SALTS.—In an article which appeared in *Kali*, No. 3, 1921, the writer, Mr. O. Krull, dealing with the manufacture of potassium chloride, describes the *modus operandi* which enabled him to determine the solubility and speed of dissolution of chlorides of sodium and potassium, both separately and mixed. He then applies the data found to the industrial treatment of sylvinite, and notes that regularity in the composition of sylvinite is the most important factor for satisfactory manufacture of potassium chloride.

THE BROMINE INDUSTRY.—The bromine industry, almost entirely German and American before the war, had acquired a very considerable development, and is an industry deserving of note. The raw material is the mother-water from manufacture of potassium salts at Stassfurt, which contain 3 to 5 grms. of bromine in form of magnesium bromide. This water, heated to 80° C., is conveyed to the top of a tower lined with refractory materials. A mixture of steam and chlorine enters at the base, and the gaseous bromine escapes at the top to be condensed in a stone-ware worm. The bromine obtained yet contains 2·5 per cent chlorine, and must be rectified on iron bromide. Kubierschky invented an apparatus constructed on the same principles, but with a plate column, thus obtaining good anhydrous bromine, with recovery of heat from the spent mother-water and continuous rectification of the bromine in a second plate apparatus. Thus almost chemically pure bromine can be directly produced, and the entrained chlorine, escaping in a gaseous form and returning to the base of the first column, recovered.—*Industrie Chimique*, May, 1921.

NEW COMPANIES.

The under-mentioned particulars of New Companies recently registered are taken from the Daily Register compiled by JORDAN & SONS, LIMITED, Company Registration Agents, Chancery Lane, W.C.2.

DYMOND TAR CHEMICALS & FUELS, LIMITED.—(176029)—Registered July 29th, 1921. Headlands Works, Liversedge. To carry on the business of Tar and Chemical Manufacturers. Nominal Capital: £30,000 in 30,000 Shares of £1 each. Directors: H. P. Hird, Moor End House, Dewsbury Moor, Dewsbury; F. D. Richmond, Lower Popeley, Liversedge; J. Haigh, Scout Hill, Dewsbury; W. Glossop, Highfield, Hipperholme; H. A. Glover, Morley, Hipperholme; C. S. Hays, Vermont Villa, Liversedge; R. Yielding, Birstall. Qualification of Directors: 100 Shares. Remuneration of Directors: To be voted by Company.

NORMAN V. STOW, LIMITED.—(176042)—Registered July 29th, 1921. To acquire and carry on the business of Chemists, Druggists, Oil and Colourmen. Nominal Capital: £3,500 in 3,500 Ordinary Shares of £1 each. Directors: N. V. Stow, Belfield, Forde Park, Newton Abbot; G. B. Purser, 15, Abbotsbury Road, Newton Abbot (Managing Director); A. Sampson, 2, Devon Square, Newton Abbot; R. Cubitt, Clinton House, Ashburton. Qualification of Directors: £100. Managing Director: £1,000. Remuneration of Directors: To be voted by Company in General Meeting.

THOMAS ASPINALL, LIMITED.—(176048)—Registered July 29th, 1921. 6, 8 & 10, Bank Street, Bolton. To acquire and carry on the business of Manufacturing, Wholesale and General Chemists. Nominal Capital: £5,000 in 5,000 Shares of £1 each. Directors: T. Aspinall, 48, Somerset Road, Bolton; F. A. Lowe, 32, Harpers Lane, Bolton. Qualification of Directors: £100. Remuneration of Directors: To be voted by Company.

ARTHOL MANUFACTURING COMPANY, LIMITED.—(176051)—Registered July 30th, 1921. To acquire and carry on the business of Manufacturers of Synthetic Perfumes and Essential Oils of all kinds. Nominal Capital: £25,000 in 25,000 Ordinary Shares of £1 each. Directors: J. F. Barvoets, 20, Deane Road, Liverpool; R. F. Morris, Rose Bank, Wilmslow, Cheshire (Managing Directors). Qualification of Directors: One-fourth of the issued capital. Remuneration of Directors: To be voted by Company in General Meeting.

MC.INNES COMPOSITIONS COMPANY (1921), LIMITED.—176071—Registered August 2nd, 1921. To acquire and carry on the business of Anti-corrosive and Anti-fouling Compositions and Paint Manufacturers and Merchants. Nominal Capital: £50,000 in 40,000 Participating Preference Shares of £1 each and 40,000 Ordinary Shares of 5/- each. Directors: To be appointed by Subscribers. Qualification of Directors: 1 Share. Remuneration of Directors: £100 each. Subscribers: F. M. B. Fisher, 4, Cullum Street, E.C.3.; G. N. Reeves, 7, East India Avenue, E.C.3.

CARTLIDGE BROTHERS, LIMITED.—(176054)—Registered July 30th, 1921. 36a, Darlington Street, Wolverhampton. To carry on the business of Oil Merchants and Refiners. Nominal Capital: £5,000 in 1,000 Preference Shares and 4,000 Ordinary Shares of £1 each. Directors: J. H. Cartlidge, Mount Road, Penn, Near Wolverhampton; L. Cartlidge, Park Side, Etruria Road, Basford, Stoke-on-Trent. Qualification of Directors: £250. Remuneration of Directors: £100 each.

New Patents.

THIS *List is specially compiled for the Chemical News* by Messrs. Rayner & Co., Registered Patent Agents, of 5, Chancery Lane, London, W.C.2., from whom all information relating to Patents, Trade Marks and Designs can be obtained gratuitously.

Latest Patent Applications.

20331—Cumberland Coal Power & Chemicals, Ltd.—Production of solid products from ammonia gas. July 28.

20256—Dutt, E. E.—Extraction of titanium dioxide and alumina from titaniferous bauxite. July 28.
20258—Godfrey, S. H.—Extraction of titanium dioxide and alumina from titaniferous bauxite. July 28.
20417—Green, A. G.—Process for manufacture of phthalimide. July 29.

Specifications published this Week.

143850—Norsk Hydro-Elektrisk Kvaelstof-Aktieselskab.—Process for the production of formate of ammonium from barium cyanide.
166767—Dreyfus, H.—Manufacture of cellulose derivatives.
145696—Collin Akt Ges. ver Verwertung von Brennstoffen und Metallen, F. J.—Process of producing ammonium sulphate from cyanogen compounds produced in the distillation of coal or organic substances.

Abstract Published this Week.

Sulphuric Acid.—Patent No. 164572.—Mr. R. F. Dior, of 18, Rue du Dome, Billancourt, France, has obtained a Patent for an improved apparatus for obtaining sulphuric acid. In a series of sulphuric acid chambers, their size and height decrease in order, *the tallest being connected with the Glover, and the shortest with* the Gay Lussac tower. Each resembles in shape an inverted funnel, in which the sides of the upper part are more vertical than the sides of the lower part. The gases, which enter at the bottom and leave at the top, are caused to move spirally by placing the inlet and outlet respectively, tangentially to the circumference of the chamber. In order to control the flow of the gases, a vertical shaft placed in the centre of the chamber may be employed. For the same purpose, jets of steam, atomized water, or dilute sulphuric acid may be directed in a downward direction by injectors from the top of the chamber or from the sides. Sulphuric acid of about 53°, is poured continuously down the inner surface of the chamber by means of the annular groove and cap or by any other device such *as the turbine. The outer walls are kept cool by means of cold* water which flows from the trough and is collected. When four of such chambers are connected in series, the dilute acid produced in the second is used to supply the first, and that produced in the third and fourth is conveyed to the top of the second. The strong acid formed in the first chamber is partly removed from the system and the remainder is led to the third and fourth chambers. In this way the dilute acids are concentrated in the first two chambers and the nitrous gases recovered to some extent, in the last two chambers, *thereby assisting the working of both the Glover and Gay Lussac* towers.

Messrs. Rayner & Co., will obtain printed copies of the published specifications and will forward on post free for the official price of 1/- each.

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PATENTS, TRADE MARKS. Handbook and advice free—B. T. King, British and U. S. Regd. Patent Attorney, 146a, Queen Victoria St., London. 35 years reference

THE Proprietor of Patent No. 135706 for
METHOD OF MANUFACTURING GELATINE TUBES FOR MEDICINAL PURPOSES
is desirous of entering into arrangements by way of licence and otherwise on reasonable terms for purpose of exploiting same and ensuring its full development and practical working in this country. All communications should be addressed in the first instance to:
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UNIVERSITY OF ABERDEEN.

Academical Year, 1921-1922.

FACULTIES OF SCIENCE AND MEDICINE.

Winter Session commences on Thursday, 13th October, 1921, and closes on Thursday, 16th March, 1922.

Summer Session commences on Monday, 24th April, 1922, and closes on Friday, 30th June, 1922.

The Preliminary Examinations will commence on Friday, 16th September, 1921, and Friday, 17th March, 1922.

FACULTY OF SCIENCE.

The Faculty of Science embraces 8 chairs besides Lecturers by whom instruction is given in all the main departments of the Science School.

PROFESSORS.

Natural Philosophy	Charles Niven, M.A., D.Sc., F.R.S.
Physiology	John Alex. MacWilliam, M.D., F.R.S.
Anatomy	*Robert William Reid, M.D., F.R.C.S.*
Natural History	John Arthur Thomson, M.A., LL.D.
Mathematics	Hector Munro Macdonald, O.B.E., M.A., F.R.S.
Agriculture	James Hendrick, B.Sc.
Chemistry	Alexander Findlay, M.A., D.Sc., Ph.D.
Botany	William Grant Craib, M.A., F.L.S., F.R.S.E.

LECTURERS.

Veterinary Hygiene	William Brown, M.R.C.V.S., F.R.P.S.
Fisheries	Thos. A. W. Fulton, M.D.
Geology	Alfred Wm. Gibb, M.A., D.Sc.
Engineering Field Work	Alex. R. Horne, B.Sc., A.M.I.C.E.
Forestry	*Peter Leslie, M.A., B.Sc., B.Sc. (Agr.).*
Agriculture	Wm. J. Profeit, M.A., B.Sc. (Agr.).
Parasitology	John Rennie, D.Sc.
Forest Botany and Forest Zoology	Alex. S. Watt, M.A., B.Sc. (Agr.).

The Degrees conferred by the University are:—
Bachelor of Science in Pure Science (B.Sc.).
Bachelor of Science in Agriculture (B.Sc.Agr.).
Bachelor of Science in Forestry (B.Sc.For.).
Doctor of Science (D.Sc.).

Diplomas in Agriculture and Forestry are also granted.

The Inclusive Fee for instruction for the B.Sc. in Pure Science is 90 Guineas, payable in three annual instalments of 30 Guineas.

The Degree Fee is 9 Guineas, payable 4 Guineas for the first examination and 5 Guineas for the second examination.

Practical work in agriculture is carried out in conjunction with the North of Scotland College of Agriculture, which has a demonstration estate a few miles out of Aberdeen.

A number of Bursaries and Scholarships are awarded in Pure Science and in Agriculture.

FACULTY OF MEDICINE.

The Faculty of Medicine embraces 12 Chairs.

Instruction in special departments of Medical practice is given by Lecturers appointed by the University Court.

Clinical instruction is obtained in various Hospitals and Institutions in Aberdeen.

The Degrees in Medicine granted by the University are:—
Bachelor of Medicine and Bachelor of Surgery (M.B. & Ch.B.).
Doctor of Medicine (M.D.).
Master of Surgery (Ch.M.).

A Diploma in Public Health is conferred after examination on graduates in Medicine of any University in the United Kingdom.

The total cost of the whole curriculum for the Degree of M.B., Ch.B., *including Hospital Fees, Matriculation Fees and Degree* Fees, is approximately about £248.

The University also grants Degrees in Arts, Law, Divinity, Education and Commerce.

Further particulars may be had on application to the Secretary of the University, Marischal College, Aberdeen.

H. J. BUTCHART,
Secretary.

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THE CHEMICAL NEWS.

VOL. CXXIII., No. 3202.

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

THE 69th Annual Meeting of the British Association will be held in Edinburgh from Wednesday, September 7 to Wednesday, September 14.

The Inaugural General Meeting will be held in the Usher Hall, on Wednesday, September 7, at 8.30 p.m., when Sir Edward Thorpe, C.B., F.R.S., will assume the Presidency in succession to Professor W. A. Herdman, C.B.E., F.R.S., and will deliver an Address dealing with "Some Aspects and Problems of Post-War Science, pure and applied."

On Friday, September 9, at 8.30 p.m., in the Usher Hall, the First Evening Discourse will be delivered by Professor C. E. Inglis, O.B.E., M.A., on "A Comparison of the Forth and Quebec Bridges, showing the Evolution of Cantilever Bridge Construction during the past Thirty Years."

On Tuesday, September 13, at 8.30 p.m., in the Usher Hall, the Second Evening Discourse will be delivered by Professor W. A. Herdman, C.B.E., F.R.S., on "Edinburgh and Oceanography."

The Concluding General Meeting will be held on Wednesday, September 14, at 12 noon.

At the Inaugural Meeting, Members of the General Committee may occupy the raised seats on the platform. In the area a few rows only will be required for official use. At the Evening Discourses, a limited number of seats on one side of the hall only will be retained for the General Committee and official use. To all other seats, the whole of which command uninterrupted view and hearing, the Membership Ticket will admit, without further ticket.

Four Public Lectures to Citizens will be given by Members of the Association in connection with the Meeting.

On Tuesday evening, September 6, at 8 p.m., in the Usher Hall.—Sir Oliver J. Lodge, F.R.S., on "Speech through the Ether, or the Scientific Principles underlying Wireless Telephony."

On Wednesday afternoon, September 7, at 2.30 p.m., in the Natural History Theatre, Old College University.—E. J. Russell, D.Sc., F.R.S. (special lecture, arranged in collaboration with Section M, Agriculture, on behalf of agricultural interests in Edinburgh and neighbourhood), on "Science and Crop Production."

On Thursday evening, September 8, at 8 p.m., in the Usher Hall.—Professor A. Dendy, D.Sc., F.R.S., on "The Stream of Life."

On Monday evening, September 12, at 8 p.m., in the Usher Hall.—Professor H. J. Fleure, D.Sc., on "Countries as Personalities."

Arrangements for these Lectures are in the hands of the Local Executive Committee, in collaboration with the local branch of the Workers' Educational Association.

Sectional Addresses.—The following Addresses will be given by Sectional Presidents. These Addresses will be distributed throughout the programme, and those marked * will be introductory to discussions:—

A—Problem of Physics. By Prof. O. W. Richardson, F.R.S.

B—The Laboratory of the Living Organism. By Dr. M. O. Forster, F.R.S.

C—Experimental Geology. By Dr. J. S. Flett, F.R.S.

D—Some Problems in Evolution. By Prof. E. S. Goodrich, F.R.S.

E—The Application of Geography. By Dr. D. G. Hogarth, C.M.G.

F—The Principles by which Wages are Determined. By W. L. Hichens, Esq.

G—Water Power. By Prof. A. H. Gibson, D.Sc.

I—The Boundaries of Physiology.* By Sir W. M. Fletcher, K.B.E., F.R.S.

J—Consciousness and the Unconscious.* By Prof. C. Lloyd Morgan, F.R.S.

K—The Presenr Position of the Theory of Descent, in Relation to the Early History of Plants.* By Dr. D. H. Scott, F.R.S.

L—The Place of Music in a Liberal Education.* By Sir Henry Hadow, C.B.E.

The following subjects (among others) will be discussed at joint meetings of the Sections indicated: The Structure of Molecules (Sections A, B). The Age of the Earth (Sections A, C, D, K). Biochemistry (Sections B, I). The Proposed Mid-Scotland Canal (Sections C, G). The Origin of the Scottish People (Sections E, H). Vocational Training and Tests (Sections F, J, L). The Relation of Genetics to Agriculture (Sections D, K, M).

Papers read at the meeting will be published in the CHEMICAL NEWS with as little delay as possible.

THE COLOUR OF THE LIGHT FROM THE NIGHT SKY.*

By LORD RAYLEIGH, F.R.S.

THE general light of the sky at night is very faint, and beyond the observations of Campbell (*Astr. Soc. Pacific*, 1917, xxix., 218) and Slipher (*Astr. Jour.*, 1919, xlix., 266), who could always detect the aurora spectrum line in temperate latitudes, nothing appears to be known of its spectroscopic or chromatic character. Slipher, indeed, suggested that the variability in its brightness recorded by Yntema might be accounted for by attributing the light mainly to a variable aurora. But this view has been controverted, rightly as I think, by Fabry (*Astr. Jour.*, 1919, l., 308). My own observations, now to be recorded, indicate that at the time and place where I was working, little, if any, of the light could be attributed to the green aurora line.

The great difficulty of spectroscopic observations is, of course, the want of light; though if the light were monochromatic, as, for instance, if it were all concentrated in the aurora line, this difficulty would be much mitigated. I thought it worth while, however, to try if anything could be learnt by a cruder method, which possesses some advantages even if the light is not very feeble.

*Reprinted by permission from the *Proceedings of the Royal Society*, A. Vol. xcix.

A series of small coloured filters were arranged so as each to transmit a limited portion of the spectrum. These were placed in a suitable frame, which held in addition a neutral-tinted photometric wedge of carbon in gelatine, made by Mr. Sanger-Shepherd. This wedge was graduated in equal parts, according to Hunter and Driffield's method. (Scale-reading 10, light transmitted = 1/10; scale reading 20, light transmitted = 1/100). A photographic plate was placed in the frame, so that part of it was under the various colour filters, and another part under the wedge. This could be exposed to the night sky or other source of light.

After development, the photographic intensity under each coloured screen will match the intensity under some point on the wedge. The plate, therefore, gives a record of what fraction of the total photographic effect due to the source is transmitted by each screen. For comparable results with different sources of light, it is of course necessary to keep to the same kind of photographic plate.

The great advantage of the method is that it allows light to be used from a cone of very large angular aperture. With a spectroscope we cannot, under the most favourable circumstance, use an aperture ratio of more than 1 : 2. But a plate under the coloured filters may be exposed to the entire hemisphere if desired. Moreover, when faint impressions are concerned, a large patch of defined shape and uniform, even if small, intensity practically gives much more confidence to the experimenter than a small and faint spectrum. The information given is, of course, of a rather different kind.

Coming now to details. The coloured screens were :—

		Transmission.
1.	Ultra-violet glass, supplied by Messrs. Chance	3300-3800
2.	Cobalt blue glass. Several thicknesses	4000-4500
3.	Bluish-green glass	4300-5300
4.	Green glass	5100-5900
5.	Flavazine	5500-7000
6.	Flavazine, with didymium glass	5500-5630 and 5930-7000
7.	Wratten's red filter, No. 23A	5800-7000

These were chosen, so far as possible, to give nearly the same photographic density with sunlight. This is desirable, because the range of intensities which the plate can deal with is not unlimited. The green and red filters, which transmit portions of the spectrum to which the plate is comparatively insensitive, were chosen to give as large transmission as was consistent with isolating a fairly narrow range of the spectrum.

Filter No. 6 was designed to isolate as nearly as possible the green aurora line, if present. No filter could be found to cut out the red without at the same time involving serious loss of green.

Ilford special rapid panchromatic plates were used. These were far more effective in the red, yellow, and green regions than any other plates I have tried. All the results recorded were obtained with a consignment of plates bearing the same number, and therefore, presumably, as nearly alike as may be.

An ink mark on the under face of the wedge gave a fiducial mark on the negative, and starting from this, the wedge scale was copied by hand on to the developed film, marking it on with a fine pen.

The photometric work on the developed plates was done with the photoelectric apparatus described in connection with the scattering of light by gases (*Proc. Roy. Soc.*, 1920, xcvii., 440). Briefly, it depends on a photoelectric cell with battery and galvanometer. The plate rests on a table, in which is a slit. Above is a bright light focussed on the slit with a lens. The rays diverging beyond the focus fall on the photo-electric cell. The deflection of the galvanometer depends on the opacity of the photographic film. The impression through a colour filter was placed on the slit, film downwards, and the deflection noted. The impression of the wedge was then substituted, with the length of the slit at right angles to the length of the wedge. The plate was then slid along until the previous deflection was recovered, and the postion of the slit on the wedge scale noted.

On a given negative, the result was usually recovered to within about 0·2 of a scale division, but, with another negative, discrepancies as large as 1 scale division (representing a factor of 1·26), or even more, were observed. These are due either to inequalities in the photographic film or to changes in the quality of light received from the source, due to varying atmospheric conditions (see the remarks in my paper, *loc. cit.*, p. 442. The plates used in the present work were coated on common glass, not plate glass).

The photoelectric measurement of a given negative was very satisfactory, and far preferable to visual photometry. (The latter can, no doubt, be applied to smaller areas on the negative, which is important in some investigations).

The first series of experiments was made with the plate exposed to the entire sky, so far as it was not blocked out by trees and buildings. This method is open to the objection that some of the rays pass very obliquely through the coloured screens, with the result that the effective thickness of the latter becomes somewhat indefinite. This, however, does not seem to vitiate the result appreciably, as subsequent experience showed; while an important advantage is gained in shortening the exposure.

Comparison of the night sky with the clear twilight sky (Table I.) shows clearly bow much poorer the latter is in yellow and red light. The wedge readings for tbe two yellow and the red filter differ by about 4 scale divisions, showing that, for tbe night sky, the yellow and red components account for 2·5 times as large a percentage of the wbole photographic effect as in the twilight sky.

TABLE I.

The Figures given are the Wedge Readings, obtained as described.

	Starlight sky. Aug. 9.	Starlight sky. Sept. 6-7.	Twilight, clear sky. Aug. 17.
Ultra-violet glass ...	10·6	10·0	9·9
Cobalt glass	13·1	13·3	12·4
Bluish-green	12·5	12·2	11·3
Green	14·7	13·7	16·1
Flavazine	8·5	8·0	13·1
Flavazine with didymium	12·1	10·9	16·1
Red	10·7	10·0	15·0

TABLE II.

	Starlight sky. Sept. 15-16.	Starlight sky. Oct. 8, 9, 10.	Starlight sky. Mean.	Blue sky at sunset. Sept. 27.	Blue sky at sunset. Sept. 28.	Blue sky. Sept. 24. 1 p.m.
Ultra-violet glass	13·2	11·9	12·6	12·3	15·4	10·4
Cobalt glass	14·9	14·8	14·8	13·5	12·8	14·0
Bluish-green	11·8	12·3	12·0	11·9	13·3	12·8
Green	13·5	14·7	14·1	16·3	17·2	17·6
Flavazine	8·5	8·5	8·5	12·9	15·1	13·9
Flavazine with didymium	11·5	11·6	11·0	16·6	17·0	18·0
Red	9·9	11·0	10·9	14·3	16·2	16·3

	Sun, 33° up. Sept. 22.	Sun, 33° up. Sept. 28.	Sun, 33° up. Sept. 28.	Moon, Sept. 26, Moon 33° up.		Basalt, fresh.	Basalt, weathered.
Ultra-violet glass	14·9	15·8	14·9	14·9	15·0	14·9	16·2
Cobalt glass	14·3	15·2	14·6	15·2	15·0	14·4	15·6
Bluish-green	11·7	12·0	13·2	11·4	12·0	11·3	11·5
Green	13·2	14·1	15·5	14·0	14·2	13·1	12·3
Flavazine	7·0	8·0	8·8	7·5	7·4	7·8	5·5
Flavazine with didymium	10·7	11·0	12·2	11·3	10·7	10·6	8·8
Red	9·0	10·8	11·5	9·5	8·7	9·3	7·4

The next series of experiments were designed to include in the comparison the direct light of the sun and moon. These give approximately parallel rays, which traverse the absorbing screens normally. For comparison with them, it is desirable to restrict the cone of rays from the night (or day) sky as far as other conditions will allow. An aperture, 15in. in diameter, was placed 15in. from the plate. This aperture was the smallest that could well be used. The work was carried out in August and September and early October, when the hours of complete darkness are very limited. Summer time imposes a further obstacle The moon must be below the horizon, and the night should be clear. With the aperture ratio 1 : 1, as described, about nine hours' exposure were needed to give satisfactory intensity.

Two plates with this exposure were all I could get before my enforced return to London in October. The exposures were made at Beaufront Castle, three miles from Hexham, Northumberland, and also at Terling Place, Essex. There was no appreciable interference from town light, diffused by the sky.

In making exposures to direct sunlight, the difficulty was to reduce the photographic effect sufficiently. The ideal method would be to use a pinhole camera, giving an image of the sun which would cover the quarter plate used, but this involves an impractically long camera. To work at a reasonable distance, more divergence of the rays is essential. It was got by means of a quartz lens, of 7 mm. diameter and 9 mm. focus. The plate was placed on the axis of the lens, at about 60 cm. distance, when the divergent cone of rays from the image covered an area more than large enough The lens was mounted in the end of a blackened box, with a kodak photographic shutter over it. The plate holder, carrying the coloured screens and photometric wedge, was introduced at the other end of the box. A simple shadow arrangement was provided for pointing the axis of the lens at the sun.

A quartz lens was used, so as to avoid any absorption of ultra-violet light, or any risk of introducing colour which might disturb the comparison of sunlight with other sources.

Exposures were also made on direct moonlight. For these, no special arrangements were needed, as an exposure of several seconds proved suitable. The results are given in Table II.

In considering these results, it will be noticed in the first place that the wedge readings for cobalt glass and bluish-green glass respectively are nearly the same whatever the source of light. This merely expresses the fact that by far the greater part of the photographic effect of the spectrum is due to the kind of light which these glasses can transmit. In any case, the ultraviolet or red ends of the spectrum produce a comparatively small fraction of the whole effect, consequently the absence or presence of these constituents hardly affects the wedge reading for the blue.

It is in the case of the ultra-violet at one end of the spectrum and the yellow and red at the other that enough variability is to be expected to give information as to the constitution of the source.

The ultra-violet constituent tends to be variable for plates obtained on different occasions. This is not surprising when we consider that this constituent is largely affected by atmospheric absorption, and is therefore sensitive to atmospheric conditions, even when the sky is apparently clear. For the same reason this constituent will be largely affected by the altitude of the source. Thus he sun and moon, both exposed to at 33° altitude, are at a disadvantage compared with the zenith sky.

For these reasons not much can he inferred from the ultra-violet data. It is noteworthy, however, that the zenith sky seems much richer in this constituent when the sun is high, than at sunset. This may be accounted for by atmospheric absorption of the rays from the low sun before they reach the observer's zenith, and are scattered towards him by the air.

The great superiority of the night sky over the day sky in yellow and red light is again apparent, amounting as before to about 4 scale divisions (a factor of 2·5).

The night sky also differs very little in quality from direct sunlight. It is only in the ultra-violet that any definite distinction is apparent, and as

already remarked, the zenith sky would have an advantage in this region on account of less atmospheric absorption.

No definite distinction can be made from these experiments between the chromatic constitution of sunlight and that of moonlight. The numbers found are same within the limits of experimental error.

We may say therefore that the night sky is found to be of the same colour as direct sunlight or moonlight, but much yellower than the clear day sky.

Colour of Moonlight.

What we can see of the moon's surface suggests that it consists of volcanic rock, and the light is, of course, diffusely reflected sunlight. It occurred to me, in connection with the present experiments, to include in the comparison sunlight diffused from specimens of terrestial volcanic rock. These exposures were made when the sun was 33° up, so that atmospheric absorption should be as nearly as possible the same as when the moonlight exposures were made. The photographic plate was placed in the box used for exposures to direct sunlight, but the quartz lens was removed. The iris diaphragm attached to the shutter was adjusted so as to subtend half a degree at the photographic plate—the same angular diameter as the moon—and it was backed with the specimen of rock in full sunlight placed near the aperture. The same exposure was given as was given to direct moonlight. Only two exposures were made, one to a specimen of fresh basalt, and another to a weathered ochreous surface of the same. The light from the fresh basalt cannot be distinguished definitely in quality from moonlight or sunlight, but the light from the weathered basalt appears to be distinctly yellower than moonlight. The experiments are too few for a final conclusion, but they suggest that the surface of the moon is more like the fresh than the weathered specimen. This is in accordance with the absence of a lunar atmosphere. (These experiments on rock were hampered by the fact that the photometric apparatus was not at hand when the exposures were made. They are merely of a preliminary character).

Visual Observations on the Night Sky.

The conclusions reached, photographically, on the night sky are entirely confirmed by visual observation.

The photometric comparison of lights of different colours is, under ordinary circumstances, difficult and embarrassing, and little definite significance attaches to the results. But with lights below a certain intensity this difficulty disappears, since there is no longer the power of colour discrimination, and vision is monochromatic. A confident decision can then be given as to which of two lights appears brighter, whether they are of the same spectral quality or not. This is, of course, well known, and is fully elaborated in works on colour vision.

Two gelatine films on glass were prepared, one dyed yellow with flavazine, and the other with methylene blue, the intensity of the latter being adjusted by washing out some of the colour until right for getting the effects which will now be described. The two films were mounted edge to edge at the end of a pasteboard tube, so that, when the tube was directed to the sky, the circular field was seen divided into two along a diameter.

During the daytime the yellow film was considered by all observers to be the brighter. As twilight advanced, the Purkinje phenomenon came into evidence, and the blue film became brighter. This remained the case when the light had waned so far that the colour sensation had disappeared. As the stars came out, the predominance became less marked, and, before the Milky Way was distinguished, there was equality. Finally, when the Milky Way was conspicuous, the yellow film was notably brighter, whether the tube was pointed to the Milky Way or to other parts of the sky.

Another pair of films was prepared, giving equal intensities when the night sky was viewed. In this case, still more than in the previous one, the blue half appeared brighter while any twilight remained. (A preliminary notice of this result was published in a letter to *Nature*, dated August 20, 1920).

It was desired to confirm visually the conclusion reached by photography that the colour of the night sky was nearly the same as that of direct sunlight or moonlight. Moonlight was chosen, as being of more convenient intensity. It was found that the yellow and blue films, which appeared equally bright against the night sky, also appeared equally bright when viewed against a white cloth exposed to direct moonlight. This background was, however, somewhat too bright, and, in order to get rid of colour perception, it was found advisable to reduce it twelve-fold by means of Fox Talbot's revolving sector. It was then impossible to distinguish between the two coloured films, which appeared of exactly equal intensity.

The night sky was examined on many occasions through the pair of films, which gave equal brightness. I never observed any marked deviation from equality, at considerable altitudes, though low down the yellow often had an advantage. This is probably attributable to selective atmospheric absorption. The experiments gave no evidence of a variable colour such as might be produced by an aurora of variable intensity.

I may add that my own attempts to see or photograph the aurora line on ordinary nights have had no success. All that I could see was a continuous spectrum. *Note added, March* 4.—I have since succeeded in regularly photographing the aurora line.

Summary and Conclusion.

To get the information as to the chromatic character of the light from the sky at night, photographic exposures were made under coloured media selected for isolating various parts of the spectrum. By comparing the photographic densities obtained, it was concluded that the night sky was much yellower or less blue than the (clear) day sky. Comparison with direct sunlight or moonlight showed that the night sky was of the same quality as these.

Visual comparisons through coloured films showed that a blue film, which was equally bright with a yellow one against the night sky, was brighter against the twilight sky. These comparisons were not embarrassed by colour differences, because the light was so faint as to give purely monochromatic vision. The two films matched one another equally well, whether they were seen

against the Milky Way or against other parts of the sky. In the photographic work no special attention was paid to this point, the exposures being made to a considerable area of sky around the zenith. The diurnal motion, of course, brought successive areas of the sky into action during the long exposures.

One theory of the light of the night sky attributes it to sunlight scattered by a very rare gaseous atmosphere, situated so high up as to be outside the earth's shadow. The present observations are contradictory of this theory, which would require the night sky to have the same colour as the day sky.

The comparative absence of polarisation (see Rayleigh, *Astr. Jour.*, 1919, l., 227; also Babcock, *ibid.*, p. 228) leads to the same conclusion.

The requirements, as regards colour and polarisation of the light, would be satisfied if we regarded it as coming from an unresolved background of stars. They would equally be satisfied if we regarded it as due to sunlight scattered by meteoric matter. The conclusions of van Rhyn (*Astro. Phys. Jour.*, 1919, l., 356) favour the latter alternative. He regards the general light of the sky as an extension of the zodiacal light.

THE PRESENT POSITION OF SMOKELESS FUELS.*

By F. S. SINNATT, M.B.E., M.Sc. (Tech.), F.I.C., M.I.Min.E., Lecturer in Fuels, College of Technology, Director of Research, Lancashire and Cheshire Coal Research Association.

THE commercial literature on the subject of smokeless fuels is considerable, and it appears desirable to collect together the material in order to attempt to ascertain the general lines along which the industry concerned with the manufacture of artificial fuels by carbonisation of coal is proceeding.

It is not proposed to discuss the relative advantages of gas, electricty, and smokeless fuels, but to assume that there are many people who wish to have a fire of solid fuel in certain rooms in their houses; this desire may be largely sentimental, but many hold that solid fires are more healthy. Everyone wishes to reduce the black smoke and and fog-nuisance, especially in large towns, and the householder is offered four main alternatives, gas fires, electric heating, central heating, or smokeless fuel fires.

It is generally recognised that coke, as obtained from gas-works, is not entirely suitable for combustion in ordinary grates, owing to the difficulty with which it ignites, but if a sufficient supply of good coke were available, the need for smokeless fuels would not be so pronounced. In modern gasworks there is a tendency to produce increasingly large volumes of gas, and if it is assumed that the coal-tar and ammonia are still important by-products, the increased volume can only be produced at the expense of the coke, with the result that the percentage of inorganic constituents in it becomes excessively high, and cases can be cited of coke containing as high as 20 to 30 per cent of ash and a considerable percentage of water. Such fuel as this is not suitable for domestic fires, and to offer such material for household purposes is an injustice to the small consumer who is at the mercy of the gasworks, and an injury to the movement for the wider use of this fuel. This tendency in modern gasworks reaches its culminating point in the comparatively modern process of converting the whole of the coal into gas, without producing any coke. The consequence of the above is that many households which formerly used coke have now to burn coal if they wish to have a solid fuel. It therefore appears that, although the larger production of gas is a step forward, and leads to a decrease in the smoke nuisance, there is, on the reverse side, a greater use of coal to replace the coke which was obtained from the gasworks. The shortage of suitable coke makes it desirable for the industry producing smokeless fuels to be developed in order that a supply should be available.

Many of the processes for the manufacture of smokeless fuel are in an experimental state, but certain of them have made sufficient progress to indicate that they may become large industrial processes.

Requirements of Smokeless Fuel.—The manufacture of smokeless fuel is, in itself, a sufficient incentive for the carbonisation of coal at a low temperature, but the principle involved has certain additional advantages which must receive notice. Thus, the weight of the products per ton compared with those obtained in ordinary gasworks, is as shown in Table I.

The amount of tar obtained is much greater than that obtained at a high temperature, whilst the amount of ammonia and the volume of gas are considerably less. The efficient separation and utilisation of the tars from the low temperature carbonisation of coal have not been completely solved, and considerable research work is still required. The products from the tar are compounds, belonging to the aliphatic or associated series, as distinct from those present in the tar from the high temperature carbonisation, which contains compounds of the benzene series. Both these series of compounds have special commercial applications, but whereas the benzene (high temperature carbonisation) is of vast importance to the following industries—coal tar colour, disinfectant, motor fuel, and explosives—the compounds obtained from the low temperature carbonisation are chiefly of importance in two industries only, for motor fuels and for lubricants. It is obvious that the products are not so valuable as those obtained from ordinary coal-tar.

The volume of gas produced is considerably smaller than in high temperature carbonisation, but it would appear that this gas may find other application than burning for ordinary purposes.

The reasons for the necessity for smokeless fuels are economy in the burning of coal, shortage of coke (and that available is of inferior quality), reduction of the number of fogs, economy due to clean buildings, reduction of the amount of washing and cleaning in the household.

Smokeless fuel should possess some of the following characteristics: It must be smokeless and ignite with ease; it should not be too fragile so that it can be handled with safety, and should not be too bulky; should not absorb water, and, if it becomes wet, it should dry in a reasonable time. It should have a low ash-content, which should

* Excerpt from the *Journal of The Royal Sanitary Institute*, 1921, xlii. No. 1.

TABLE I.

	High Temperature Gas Works.	High Temperature Coke Oven.	Low Temperature.
Gas	12,000 cu. ft. (550 B.Th.Us.)	11,500 cu. ft. (450 B.Th.Us.)	6,000 cu. ft. (750 B.Th.Us.)
Tar	10 gallons	8 gallons	20 gallons
Coke	13½cwt.	14·4cwt.	14·5cwt.
Ammonium Sulphate	25lb.	28lb.	15lb.

TABLE II.—*Smokeless Fuels: Chemical Analyses.*

Percentage.	Lignite Low Temperature.	Carbo-coal	Briquette Sun Fuel Co.	Hargreaves Coke.	Special Briquette.	Low temp. Carbon Coke.
Water	6·44	2·03	3·10	0·60	2·60	2·42
Ash	16·85	15·66	10·48	10·70	9·00	4·70
Volatile matter	22·43	5·94	10·08	7·80	13·00	15·45
Volatile organic matter	15·99	3·91	6·98	7·20	10·40	13·03
Coke	77·57	94·06	89·92	92·20	87·00	84·55
Fixed carbon	60·72	78·40	79·44	81·5	78·00	79·85
Calorific value B.Th.U. per lb.	10,280	11,570	12,740	13,180	12,400	13,550

not be powdery; must contain only a small percentage of sulphur; must be of a porous nature so that its combustion will not take place only from the outside, but enter into the texture of the material, in order that the ash which is formed does not cover the surface of the fuel and prevent combustion.

The following is a list of smokeless fuels with which the author is acquainted: Low Temperature Carbonisation Fuel, Tarless Fuel, Carbocoal, Coke Briquettes, Lignite Utilisation Board Fuel and Exors, J. Hargreaves Coke. Others have been mentioned in the literature, but no specimens have been examined by the author.

Low Temperature Carbonisation Fuel.—The coal used is washed bituminous slack, and is conveyed into hoppers which contain the exact charge required for a retort. The charge remains in the hopper until the previous charge in the retort is carbonised, and during this period it absorbs an appreciable amount of heat from the tops of the retort. Between the hopper and the retort is a rotary door, which, when open, allows the coal to fall gently into it. At the bottom of the retort is a similar rotary door for discharging the product. Below this door is a gas-tight chamber, into which the material is admitted when the carbonisation is complete, and it remains here until the succeeding charge is ready to leave the retort. When the coke door is opened, the original charge, which has now become quite cool, passes from the chamber. The low temperature coke is kept within the air-tight chamber in order to prevent loss of volatile constituents and deterioration due to burning in the air, and it was found objectionable to cool it by means of steam, as this changed the colour from black to grey. The retorts are built of refractory material, but experiments are in progress on the use of cast-iron, in order to ascertain whether this can be applied The figures given in Table I. are quoted from a paper by Mr. Davidson, given before the Institution of Engineers, Bradford, December 13, 1920.

Tarless Fuel.—This process indicates a novel treatment. The coal was carbonised in specially designed (Tozer patent) vertical retorts of cast iron, arranged so that the coal was carbonised in layers not thicker than about 5in. The carbonisation was carried out at about 550-600° C. under a pressure of about 3in. of mercury (vacuum 25in. of mercury). The products of carbonisation were drawn from the coal, leaving a residue which was a perfect smokeless fuel.

Carbocoal.—The manufacture of carbocoal introduces a new principle: The pulverised coal is fed into horizontal retorts, 20ft. long, 7ft. in diameter, lined with carborundum, and fitted with two overlapping series of arms attached to two revolving shafts. The coal is stirred throughout the low temperature carbonisation, and is gradually forced to the outlet of the retort, where it is automatically discharged. This process is a continuous one, and is conducted at a temperature of about 500° C. The coke obtained by the above treatment is in a state of very fine powder, and from the ordinary point of view is valueless. It is, therefore, mixed with pitch as a binding material obtained from the oils distilled in the plant, and made into briquettes, generally egg-shaped; the briquettes are fed into an inclined retort, heated to a temperature of 1000° C. The coke and pitch now undergo a second carbonisation at the temperature generally prevailing in ordinary coal gasworks. The result is that the coal is deprived of practically all its volatile products, and the pitch is also decomposed, whilst the fuel which leaves the plant is a coke-briquette. The fuel has certain distinct features: it is compact, tenacious, non-fragile, but, from experiments carried out by the author, somewhat difficult to ignite.

Lignite Utilisation Board Briquettes.—This process has been designed specially to deal with the lignite which has been found in large quantities in Canada. It consists in carbonising the material in a finely pulverised state, in a retort so inclined that the material is fairly free in moving through it. The lignite is non-caking. The carbonisation is carried out at a low temeperature, and the resulting coke is mixed with a binding material and briquetted at a temperature of about 300° C. The resulting fuel is a perfect type of briquette, which is practically smokeless. This process is of some interest in view of the large amount of lignite which is available throughout the British Empire, and which has not received the attention it merits, largely owing to the fact that its calorific value appears too low to be an economical

product to work. It would appear that by carbonising and subsequent briquetting, it is possible to convert it into a fuel having a distinctly high calorific value (see analyses).

Carbon Smokeless Fuel Briquettes (Sun Fuel Co.).—One part of bituminous coal is mixed with three parts of anthracite coal (by weight), and water is added to the finely powdered mixture up to about 12 to 15 per cent. The stiff paste thus formed is pressed into two sets of moulds, which, when placed face to face, are automatically locked together, and passed through a carbonising chamber at 700 to 900° C. for 15 minutes.

The volatile matter evolved amounts to about 14 to 17 per cent, and the resulting briquette is a coked mass, in which the carbonisation of the bituminous coal has led to the agglutination and binding of the anthracite.

The proportions of bituminous and anthracite coal may be varied according to the quality of the former.

Exors. J. Hargreaves Low Temperature Coke.—Experiments have been carried out upon the low temperature carbonisation of coal in a modified coke-oven, with a view to determining whether a suitable product could be obtained. These have proved successful, and a compact fuel has been produced containing up to 12 per cent of volatile matter, and burning freely. The coal used was Mountain Mine coal, which has a very high caking power. The product is a very excellent smokeless fuel.

Testing Smokeless Fuels.—No convenient method of determining the relative values of different smokeless fuels has been developed Trials on a standard grate are laborious and impossible for the ordinary consumer. It was, therefore, considerd to be of interest to place on record the values for two requirements, which are of some importance, the proportion of volatile matter present and the texture or micro-structure of the coke. These two features are important, as they indicate the approximate properties and the ease with which the fuel will ignite and continue to burn. Fuels low in volatile matter will be difficult to ignite, and burn sluggishly. If the texture is very porous, the material will be fragile and burn rapidly, whilst if too compact the reverse will be the case.

Table II. shows the approximate analyses of specimens which the author has received. It should be recognised that the percentage of ash depends largely on the kind of coal used.

Conclusion.—From the above it will be gathered that the industry is, at present, in its infancy, relatively to the coal-gas, coke,, or coal industry, and that in this country, with the exception of the Low Temperature Carbonisation process, it may be said to be in an experimental state. It appears desirable that collieries or gasworks, or both, should undertake the manufacture of some type of smokeless fuel. Such an undertaking would solve the problems of fuel-conservation, air-pollution, and efficient heating for our houses. Under such an ideal state of affairs the coal could be worked at the pithead, or in conjunction with coal-gas.

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THE RAJPUTANA SALT INDUSTRY.

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THE whole of the tract of country knowns as Rajputana is, generally speaking, saline in character. Most of the deeper wells are brackish, and in the summer months the water in certain areas is undrinkable. The people depend largely on rain-water, which is conserved in tanks or stored in small reservoirs constructed underground. For a few months after the rains, however, fresh water in small quantities is to be had a few feet below the surface, and this is obtained from shallow holes dug in the sand.

All the natural depressions in the country are capable of producing salt. The most important of these is the salt lake at Sambhar which is the largest of its kind in India. It lies at an elevation of 1184ft. above sea-level. In shape it is somewhat oval, with a length, from east to west, of about twenty miles, and abreadth varying from two to seven miles. On the west it is bounded by the Aravali range of hills; on the other sides there are vast sand plains. In area it is about 90 square miles. The bed slopes very gradually to the centre, where the depth, when the basin is full, is about 4½ft. A little over 100 years ago, the water stretched for 50 miles, and there is no doubt but that the two depressions in the neighbourhood, known as the "Nallia Sur" and the "Julga," which are now separate lakes, were at one time merged in the great lake.

Local tradition ascribes the formation of the lake to the gift of the goddess Sakumbri Devi, the tutelary goddess of the Chauhan Rajputs, who, in return for milk supplied to a religious ascetic in A.D 551, converted the forest into a vast plain covered with gold and silver. As the inhabitants of the locality regarded the gift more in the light of a curse than a blessing, fearing it would excite the cupidity of the neighbouring clans, the goddess turned the precious metals into salt which the rain dissolved and washed into a natural hollow, thus forming a lake. It is a pretty story, and one that is still credited by the simple-minded Rajput folk. In 1870, when we finally took over the administration of the lake, a peculiar incident occurred which greatly excited the people, as they thought we had discovered the means of winning back the original gift of the goddess. The Government chemical analyst, in search for a little pure silver, converted some metallic silver into chloride of silver, and mixing this with some borax to act as a flux, placed the whole white mass in a crucible and made it over to a village goldsmith to be reduced to its metallic form. When a sufficient degree of heat had been reached the workers were astonished to see molten silver in the crucible. The *rationale* of the process had to be explained to the local state officials and the leading men of the town before they would be convinced that there was no magic about it.

Science teaches us that the large majority of the salt lakes of the world have been formed, either by isolation of bodies of sea-water or by the solution of rock-salt, or by the combination of the two. Good examples of these processes are the Dead Sea, and the Bitter Lake in the Suez Canal; but there are other lakes, such as Lake Oroomiah in Persia, which are formed by rainwater and

streams dissolving effloresced salt and carrying the brine into natural basins, which, having no outlet, concentrate by evaporation. In regard to the Sambhar lake, it was thought at one time that the formation of the depression and the salinity of the water were caused by subterranean rock solution; but borings have failed to show any trace of rock salt underlying the bed of the lake, nor is there any evidence of such salt anywhere in Rajputana. The theory, therefore, that the salt in the lake is derived from the denudation of the rocks of the surrounding country which were once assumed to belong to the Permian system, a system abounding in limestone and salt, does not appear to be the correct explanation. It was also conjectured that, at some past period of the world's history, the sea receded from the present sandy wastes of Rajputana, leaving the soil impregnated with salt, which was gradually washed by rain into the natural depressions in the country. As millions of tons of salt have been taken out of the lake in the past, and spontaneous or naturally-formed salt is no longer obtainable, it was thought that the supply of salt was becoming exhausted; but investigations made by Sir Thomas Holland and Dr. Christie show that there has been no appreciable diminuution of the stock of salt, which is sufficient to meet all demands for a practically unlimited period; and, moreover, that the supply is being contributed to from year to year by dust salt brought in by the summer winds from the sea. The disappearance of spontaneous salt is due entirely to the inflow of silt, which has buried a large part of the bed of the lake.

In a paper on "The Origin of the Salt Deposits of Rajputana," published in the Records of the Geological Survey of India in 1909, Sir Thomas Holland wrote:—

"Investigations have shown that the salt resources of Sambhar are confined to a body of saliferous silt, stretching over an area of 80 to 90 square miles, and attaining depths in the centre of 60 to 70 feet. The analyses made of samples taken at regular intervals over the lake-bed show that in the upper four feet of silt, over an area of 63 square miles, there is an accumulation of more than 18,000,000 tons of salt." In regard to the salt blown in from the sea, it is stated that it is "brought in in the form of fine dust by the strong south-west winds that blow across the salt-encrusted region of the Runn of Cutch during the months of April, May, and June of each year," and that in the monsoon "the finely-divided salt dust that may have reached the heart of the desert is washed into the hollows occupied by brine lakes."

The upper two feet of the bed of the lake are composed of black, fœtid mud, giving off sulphuretted hydrogen, derived from the decomposition of animal and vegetable matter, which is the cause of the characteristic and unpleasant smell often noticeable.

The lake has no outlet, but there are four streams—the Menda, Rupnagar, Kharian, and Khandel—which flow into it. These streams, with their tributaries, drain an area of no less than 2200 square miles; consequently, in a year of heavy rainfall, such as 1917, when the fall measured over 41in., as against an average of 20in., the lake fills to overflowing. In the early summer months, when the lake is dry, the glare and heat are intolerable, and the whole country presents a picture of the greatest desolation; but during the rains a marvellous change takes place. The scenery then is exceptionally fine, and the sunset effects are the most gorgeous I have witnessed on the plains of India. Particularly interesting is a visit on a breezy moonlight night to the embankment which guards the salt works from the main body of the lake. The heaving mass of water, the sparkling, foam-crested waves, the boom of the surf, the smell of the air, all remind one of the sea, and, as one gazes westward, visions of white cliffs emerge from the background of the sky.

The lake lies within the boundaries of the States of Jaipur and Jodhpur. The western half is owned by Jodhpur, while the eastern half is owned jointly by the two States. The population in the neighbourhood is sparse, owing to the sterility of the country, but there are two towns, Sambhar and Nawa, wit ha population of about 12,000 and 5,000 respectively, situated on the shores of the lake itself. The lake was worked by the Emperor Akbar and his successors up to Ahmad Shah, when it reverted to the Rajput Chiefs of Jaipur and Jodhpur. From 1835 to 1844 it was worked by the Indian Government to repay them for compensation due and expenses incurred in repelling the predatory raids of the Rajput tribes in British India. On February 1, 1870, it was leased to the Indian Government, since when it has remained under our administration. The principal object which Government had in view in obtaining a lease of the lake was to increase the supply of salt and reduce its price in the United Provinces of Agra and Oudh by providing skilled supervision and improving communication between it and the markets. Prior to its acquisition by the Indian Government, the Salt Department of Northern India, then known as the Inland Customs Department, was not concerned with the manufacture of salt. The great Customs Line—a chain of posts, 2472 miles in length—stretched across India from Torbela on the Indus to the Mahanadi, in the Central Province, and duty was collected at the *chaukis* on the line on salt coming up from the Rajputana sources, destined for British India. By 1878 the Indian Government had assumed the management of the remaining sources in the Jodhpur State, and had negotiated treaties with all the other Rajputana Chiefs within whose territories salt was being manufactured, enjoining the closure of the works, on payment of compensation, or the restriction of the output at works left open under the management of the Darbars. Duty was now levied at the sources and the Customs Line abolished. The sums paid under these treaties to the Darbars, including the payments made for the Sambhar lake, amount to nearly 35 lakhs of rupees a year, and some of the principal States also receive a fixed quantity of salt yearly, either free of price and duty or on payment of half the duty only.

In the early years of our management, the Sambhar lake had not the importance which it now possesses as a source of supply. The average quantity of salt annually manufactured during the six years from 1870-71 to 1875-76 was 16,56,956 maunds, whereas the average quantity put up during the past six years was 55,63,265

The greatest quantity manufactured in any one year was 1,11,90,738 maunds in 1918-19. Since *1870, the lake has yielded over 20 crores of* maunds of salt. Sambhar salt is in general use throughout Rajputana, and is extensively consumed in the United Provinces and Central India. Lesser quantities are exported to the Punjab and Bihar. During the war, when the supply of imported salts fell off, the demand for Sambhar salt from Bihar rose considerably and some was also sent, for the first time, to Bengal. Now that *foreign imports have increased, the demand from* Bengal has practically ceased, while the exports to Bihar have fallen to about one-fourth of the war-time demand; but the quantity is still about five times as much as in pre-war times.

In the dry, hot air of the desert, eveaporation is rapid, and within a few months after the rains, in a year of normal rainfall, the waters of the lake contract and gather towards its central and *deeper parts, where, after further evaporation,* a wide bed of spontaneous salt is exposed to view. Owing, however, to the belt of soft mud by which this salt is surrounded, it is impossible, except at a prohibitive cost, to gather it and bring it to store. Spontaneous salt is, therefore, no longer gathered, and all the salt now obtained from the lake is manufactured. Salt is won by two methods: from permanent salt works constructed *in the bed of the lake and called kyars, and from* shallow pans of a temporary nature constructed on the lake shore. The former are worked by the Department and the latter by contractors. A kyar is a large rectangular enclosure divided into pans and protected from the lake water by high embankments pitched with stone. Alongside the kyars are platforms for the storage of salt and reservoirs for brine. Before the monsoon sets in, the mother-liquor (otherwise known as "bitterns") which is the concentrated residual brine from which the salt has separated, is pumped out of the pans, which are then cleaned and prepared for the following season's crop. As soon as the rains have ceased, the sluice gates of the reservoirs, which have been left open during the monsoon for the admission of brine, are closed, and as much extra brine as the reservoirs will hold is pumped into them. If the rains have been heavy and the kyar pans are flooded, the excess brine is pumped out, while if they are not full enough, brine is added. In a normal year the brine in the pans, after the rain, has a density of about 10° Beaume, and it is the object of the manufacturing officer so to keep his pans supplied with brine as to have a depth of 12in. when the density has risen by evaporation to 25° B. This will leave him about 4in. of brine when the density has reached 29° B. or 30° B., when extraction of salt begins. This depth of brine is essential to keep in solution the magnesium and other undesired salts which may he present and is also required for the washing of the gathered salt.

The lake brine is a complex solution of sodium chloride (sodium sulphate, sodium carbonate, calcium carbonate, and a trace of magnesium salts. Now the object of the salt manufacturer is to extract the sodium chloride as free from the other salts as circumstances will permit. To enable him to do this, it is necessary that he should not only be acquainted with the various salts in the brine, but should also study their behaviour and mutual reactions in solutions of various degress of concentration at different temperatures. An instrument, known as Beaume's hydrometer, designed to show the density of fluids, will tell him how the evaporation of his brine is progressing, and what changes are taking place in it; but, as the presence of other salts in the brine affect its reading, experience alone will enable him to correct the error in practice, and visual examination of the salt crust, from day to day, will help him to decide when to begin extraction and when to stop it. Further, it is imperative that he should observe closely all changes in the weather, as such changes materially affect the quantity and quality of the salt manufactured.

The extraction of salt at the lake is done entirely by manual labour. As soon as the salt has formed, labourers—men, women, and children—enter the pan and gather up the crust into small *heaps. Some skill is required in this operation to* avoid taking up the mud on which the crust lies. After the heaps have been thoroughly washed with residual brine and allowed to dry, the salt is carried in baskets, by headloads, and in bags on buffaloes, to the storage platform, where it is built up into conical and oblong pyramids, sloped to an angle of 36°—the angle of repose for granular, loose salt—and containing from 50,000 to 1,00,000 maunds each. These heaps are beaten and smoothed as a protection from rain, but not covered. The wastage amounts to about 3in. of surface salt per annum. Formerly payment was made on estimation at the close of the day's work to each labourer separately for the salt he had put up. This necessitated the making of innumerable little heaplets on the storage platform preparatory to the removal of the salt to the main heap. Now a very much better system has been introduced, and has resulted in a considerable saving of time and energy to all concerned. A contractor has been appointed, and the labourers are paid by him for each basket of salt as it passes his overseer on its way fro mthe pan to the main heap, the contractor himself being paid on the estimated contents of the main heaps, payment being made fortnightly.

If extraction is begun at the right time, and all dirt and insoluble matter washed or peiked out, Sambhar kyar salt is of excellent quality. The crystals are large, hard, and white. Representative samples have on analysis been found to con*tain over 99 per cent of sodium chloride.*

Pan salt is made by private contractors in shallow pans on the shores of the lake. These works are of a temporary nature, constructed each year after the monsoon. Brine is obtained from wells dug in the bed of the lake. The produce is white, and of fair quality, but, as the crystals are small, due to the shallowness of the pans used, this variety is not much in favour with traders as *it loses weight in transit.*

Twenty years ago there were eleven kyars at the lake, covering an area of about 736 acres; but two more kyars have since been constructed and it is proposed to add another. As the labour formerly employed by pan contractors is now employed in the kyars, the manufacture of pan salt is fast dying out.

The cost of production is about 1 anna and 2 *pies per maund of kyar salt, and 7½ pies per*

maund of pan salt. These figures include the cost of upkeep of works and interest on capital sunk. The salt is sold at the source at a uniform price of 4 annas a maund, and the duty is Rs1-4-0 a maund.

As will already have been noticed, the manufacture of salt at the Sambhar lake is dependent to a large extent on the monsoon rainfall. Given favourable conditions, no more than two crops of salt can be obtained in a season with the existing plant; but, as even this quantity is barely sufficient to meet the demand, the difficulty experienced by the Department when the monsoon fails can easily be imagined. Some years ago, when spontaneous salt could no longer be obtained at a reasonable cost, the works were enlarged by the addition of two kyars, and canals were constructed in the bed of the lake for the supply of subsoil brine; but the latter have not proved a success as they silt up very rapidly and cost a great deal to keep in working order. Moreover, the salt produced from such brine is inferior in quality.

Before the war, little, if any, effort was made to develop the sources and push sales. Times, however, have changed, and what satisfied us yesterday does not satisfy us to-day. The services of technical experts have been secured, and the aim of the Department now is, not only to meet the present demand, but to win new markets for its produce. There is no reason whatever why India should not produce all the salt she requires. With so extensive a seaboard and such vast deposits of salt as are found inland, and an ideal climate for manufacture, she ought not to have need of large imports of foreign salts. Nature has equipped her admirably with the means, and she is in a position to supply the requirements of her teeming millions without outside help.

Schemes for the thorough development of the sources have been worked out by experts. Some of these have, in whole or in part, been sanctioned, while others have been postponed owing to financial stringency. At Sambhar, a large reservoir—a long-felt need—is under construction. The comfort and welfare of the workers are receiving attention; and labour settlement, with comfortable quarters and a good water supply, is nearing completion. A new kyar, a central store, an efficient pumping plant, an electric installation and mechanical transport—all parts of the main scheme—are yet to come. These works will cost a substantial sum; but the money spent on them will be repaid several times over in a very short time by the profits that will accrue.

Provided, then, that the money required is sanctioned, the Department will in a few years be in a position to turn out salt of the finest quality in greatly increased quantities.—*Journal of Indian Industries and Labour.*

PHOTOGRAPHY OF COLOURED OBJECTS.—The advance in photography during recent years has been so rapid, and the results so far-reaching, that one cannot but feel surprised to read in a recent address by Sir William J. Pope, that "at the present time a very rapid panchromatic plate is on the market which is much faster to red than to blue light." Such a plate has very great possibilities.

FUEL PROBLEMS OF THE FUTURE.*

By SIR GEORGE T. BEILBY, F.R.S.

(*Continued from p. 102*).

CONSIDERING next the production in the Empi[re] outside the United Kingdom, molasses is the ra[w] material which can be converted into alcohol mo[st] cheaply. Molasses is a bye-product of sugar r[e]fining; and the quantities available for the man[u]facture of alcohol are therfore dependent on th[e] refined sugar output. The estimated Empire pr[o]duction of refined sugar in the season 1919-20 [is] just over one million tons; and the whole of th[e] resulting molasses would only produce about [1]... to 18 million gallons of 95 per cent alcoho[l]. Considerable quantities of molasses are used i[n] this country for the manufacture of industria[l] spirits. The output of the home distillerie[s] equipped for the production of molasses alcoh[ol] is limited, however, to (say) some 7 or 8 millio[n] gallons of 95 per cent alcohol; and in view of th[e] present cost of materials and labour and o[f] freight, it would hardly be a commercial propos[i]tion to erect additional distilleries here for th[e] purpose. It would be better to convert th[e] molasses into alcohol where it is produced, to us[e] the alcohol where it is made to supplement or re[]place petrol, and to export the balance. Wit[h] the present increasing output of cane sugar, ther[e] should be very considerable quantities of molasse[s] available for the manufacture of power alcohol and the possibility of utilising these molasses i[s] being brought to the notice of the authorities o[f] the countries conerned. Even in the most favour[]able circumstances, however, the quantities o[f] power alcohol available from this source must b[e] (as shown above), comparatively small, and wil[l] in the first instance mainly be used in the neigh[]bourhod of its production in replacement o[f] petrol.

Some of the legislative questions which arise in connection with the use of alcohol for power purposes have been dealt with in the Finance Bill for this session. A section of the Bill provides for the use of a new description of methylated spirits, to be called "power methylated spirits," for generating mechanical power, and for the payment of the same allowance in respect of such methylated spirits as applies to methylated spirits used for industrial purposes—namely, 3d. a proof gallon. It also gives power to the Board of Customs and Excise to make regulations as to the composition and quantity of the denaturant. A denaturant will shortly be authorised for power methylated spirits, which it is hoped will reduce to the minimum the cost of denaturing spirits to be used for this purpose. Clauses will also be inserted in the forthcoming Revenue Bill extending facilities for the importation and distribution of spirits in bulk, and enabling the Board of Customs and Excise to make regulations providing for the use of alcohol in generating mechanical power. While it is necessary, in view of the high duty on spirits in this country, to maintain some restrictions upon their use free of duty, one result of the Government action will be that the production and use of alcohol for power purposes will be much facilitated, and the expense con-

*Delivered in the theatre of the Institution of Civil Engineers, London. Inserted by favour of the *Gas Journal*, June 29, 1921.

nected with any necessary restrictions will largely disappear.

As regards the work of the past year, Sir Frederic Nathan reports that experiments carried out on the cultivation of Jerusalem artichokes have indicated that very good yields of alcohol per acre could be obtained from them. These experiments are being repeated this year; and if the previous year's results are confirmed, it may be desirable to consider the possibility of growing this tuber to supply a limited quantity of alcohol for special purposes, such as aviation. An examination of the artichoke stems has indicated that it may be possible to convert them by simple treatment to paper pulp. Should this prove to be the case, both products would be cheapened.

The investigation as to the possibilities of producing alcohol in the Empire overseas are still in progress. So far as they have gone, they indicate that in the sugar growing countries, molasses, from which alcohol might be obtained, is being wasted, but that the quantities are comparatively small, and in most cases would be insufficient to meet even local requirements for alcohol. Alcohol might be made from suitable crops grown specially for the purpose in those Dominions and Colonies where labour is available, and used to supplement or to take the place of supplies from the above sources. Some such course is specially desirable where petrol is dear and difficult to obtain—for instance, in the East African Protectorates and West African Colonies, which are, moreover, very dependent on motor transport for their development.

The use of cellulosic materials is not yet possible, because though research work is in hand to find a process that could be employed on a commercial scale in those regions where such materials exist in sufficient abundance, it has not so far led to any definite results. Where, however, materials capable of easy hydrolysis exist (as, for instance, in the case of waste rice-straw), the recent large-scale experiments in Burma, carried out under the auspices of the Burma Oil Company, appear to indicate that the joint production of alcohol and paper should be a commercial possibility (see Sir Charles Bedford, *Jour. Roy. Soc. Arts,* June, 1921).

Until alcohol can be made from waste materials which can be collected and treated at small cost, it does not seem likely that Empire-produced alcohol can be imported into this country on any considerable scale; it is improbable that it can be produced cheaply enough or in sufficient quantities from materials grown for the purpose in those overseas portions of the Empire which will no doubt before long produce it in this way for local consumption.

The Finance Bill of 1921 contains clauses giving the Commissioners of Customs and Excise powers to make regulations with respect to spirits manufactured otherwise than by distillation, and with respect to the manufacture, storage, removal, sale, use, and supply of power methylated spirits, and the importation, storage, removal and use of spirits to be used in their manufacture.

Another of the fuel problems of the future is the winning and utilisation of peat. The history of the association of the Fuel Research Board with this problem has been given in various publications of the Department of Scientific and Industrial Research. Among these, the report of the Irish Peat Inquiry Committee, of which our past President (Sir John Purser Griffith) was the Chairman, stands out most conspicuously. This subject would in itself supply material for many lectures; but on the present occasion it can only be briefly referred to in its relation to the subject of our consideration to-night.

Reference has already been made to the extensive peat developments which are in progress in Germany. These are based on the experience gained at the Wiesmoor Peat Station, which has been in operation since 1910. The peat is dredged, macerated, and spread on the surface of the bog to dry. By stacking under cover, the moisture of the peat blocks can be reduced to 25 per cent solely by air-drying. It has been stated that, prior to the war, one ton of air-dried peat containing 25 per cent of moisture could be produced for 4 marks. For steam-raising purposes two tons of this peat are equal to about one ton of coal. At the Wiesmoor Station, eight water-tube boilers are fired by peat. The new stations in Germany are being designed on a much larger scale; no effort being spared to render them as perfect as possible.

These schemes appear to ignore the fundamental difficulty which applies to the winning of peat in quantities sufficient to meet the day-by-day requirements of any large central station. When it is realised that the peat deposit in a bog 20ft. deep is only the equivalent of a 12 or 14in. seam of coal, it will be evident that even an output of 1000 tons a day of air-dried peat involves the laying-out and development of an enormous surface. At the Zehlonbruck plant, near Königsberg, it is proposed to use 920,000 tons per annum, or about 2500 tons per day.

Prof. Purcell informs me that to win mechanically 900,000 tons of air-dried peat in one season, at least 4,500 men, women, and children would be required; and the area over which the spreading and drying operations would extend could not be less than 9000 acres, or (say) 15 square miles. He suggests that in dealing with any production, over 60,000 to 80,000 tons per annum from any single district, the difficulty would increase as the square of the production.

The Irish Peat Inquiry Committee was fully informed as to the position of peat winning in Germany prior to the war, and also as to the earlier survey and investigation work of the Canadian Department of Mines. In April, 1918, a Peat Committee was set up by the Federal Government in co-operation with the Government of the Province of Ontario, to investigate the possibility of manufacturing peat fuel on a commercial scale. The Alfred Peat Bog, on which the work of the Committee is being carried out, is about 43 miles east of Ottawa, and about 70 miles from Montreal. Last summer, Prof. Pierce Purcell, the Peat Investigation Officer of the Fuel Research Board, visited the experimental station at this bog, and carefully studied the results which had been achieved under the direction of Mr. E. V. Moore, the engineer in charge. Prof. Purcell was able to watch the harvesting operation over a period of weeks, and obtained much useful information as to machines and methods. His discussions with Mr. Moore were most useful; and on his return to this country he presented to the

Fuel Research Board an Exhaustive report on his visit. During the present season Prof. Purcell hopes to visit the peat stations in Sweden, Germany, Denmark, Holland, and France. We shall thus be in intimate touch with all the more important developments which are in progress; and *the Fuel Research Board hope, by continuing the* publication of full reports, to serve as a useful centre of information on the subject.

With regard to the Board's own activities, these were necessarily seriously curtailed by the war and the post-war conditions in Ireland. Last season (1920), however, peat was cut, macerated, spread on the bog at Turraun, air-dried, and harvested.

At the beginning of the present year, 100 tons of this air-dried peat were sent to the Fuel Research Station, where some interesting experiments were carried out on its use for boiler firing and for carbonisation. The peat when it reached the Station, contained about 27 per cent of moisture. After having been kept under cover for some months, the moisture was reduced to about 17 per cent. This peat is in the form of hard blocks of various lengths, up to about 10in., with a cross section of something like 2 by 2in. Its density is rather under 1, or about twice that of the ordinary hand-cut sods made on the same bog. The blocks can be sawn and cut like hard wood; and they stand transport with very little breaking-up into smalls. In this respect they *contrast very favourably with the ordinary hand*-cut sods, which break down seriously in transport by rail or road.

The result of last year's experience at Turraun shows that:—

(1) Machine peat dries more quickly than "cut peat" under equal weather conditions.

(2) Peat spread during August, and even as late as September 3, *will have dried sufficiently—say* to 35 per cent moisture—to be used as a fuel.

(3) It was possible in the wet and unfavourable season experienced to dry three separate spreadings of peat on the same area.

(4) The peat cut and spread as early as February 5 was little damaged by the rain and frost in the early part of the year, and was harvested, although four months were required to complete the process.

(5) The peat-winning season at Turraun extended over seven months last year—namely, from February 5 to September 3.

(6) Machine peat can be "footed" when containing 75 per cent moisture or less, and may be "clamped" when containing 40 to 50 per cent moisture. Slow final drying is necessary to get the best results with machine peat; and it is advisable that this should be done in a large "clamp" —the toughest blocks being thus produced.

(7) The season referred to had been one of the wettest experienced for some years. In six out of eight months, the rainfall exceeded the average for the past five years; and although June was a dry month, there were 163 rainy days in the eight months.

Steam-raising trials at the Fuel Research Station have shown that the peat in this form is an excellent fuel. Though the evaporative efficiency actually obtained was only 65·4 per cent, this was obviously due to the unsuitability of the furnace arrangements. Further trials will be made under more favourable conditions.

Peat blocks lend themselves admirably to carbonisation, either in vertical retorts at temperatures between 700° and 900° C., or in steel retorts at 550° to 600° C. The charcoal resulting from carbonisation is an ideal fuel for suction-gas producers. The oils obtained by carbonisation are now being examined.

As coal is likely to remain the chief source of fuel, not only for Great Britain, but for the world at large, the problems of its winning, preparation, and use, still occupy the foreground in all serious consideration of the subject. In the solution of these problems there is ample scope for the skill and enterprise of an increasing number of fuel experts and engineers, not only in the pioneering work of experiment and inquiry, but in the organisation and development of new methods as these are evolved.

In seeking to come to closer quarters with these questions, it may be helpful if we can set them out with some sense of proportion and perspective as they appear from the British point of view. We know, broadly, that in normal times before the war, the annual output of coal of the mines of the United Kingdom was approximately 287 million tons, of which 189 million tons were consumed as follows:—

		Million tons.
1.	Railways	15·0
2.	Coasting steamers	2·5
3.	Factories	16·0
4.	Mines	20·5
5.	Iron and Steel	31·0
6.	Other metals	1·3
7.	Brickworks, potteries, glass, and chemicals	5·8
8.	Gas works	18·0
9.	Domestic	35·0
		189·1

If from this total we deduct items 5, 6, and 8 (iron and steel, other metals, and gas works)—together say 50 million tons—the balance of 139 million tons represents the amount which is burned in the raw or natural state of the coal. The greatest of the fuel problems of the future is to decide what proportion of this huge total it will pay to subject to a preliminary operation of carbonisation of gasification, with the object of sorting out the potential thermal units of the coal into groups of higher availability or greater convenience as fuels—*e.g.*, gas, motor spirit, fuel oils, and coke.

Though the operations of carbonisation and gasification necessarily involve the expenditure and loss of some of the thermal units of the coal, so that the collective thermal value of the new fuels is less than that of the original coal, yet the loss may be more than compensated for by the increased value of some of the new fuels.

At the prices of to-day, a "therm" in the form of coal costs from 1d. to 2d., while in the form of motor spirit its cost is from 20d. to 25d., and in the form of town gas 10d. to 15d. These figures show the premiums which can be paid for the higher "availability" of special fuels. The general recognition of the value of availability and convenience of the more costly forms of fuel must not tempt us to overlook the necessity for a criti-

cal examination of the uses to which the more expensive fuels are being devoted.

In the case of motor spirit, there is a decided tendency to regard mere convenience as a sufficient justification for its use. While for swift transport by air and by road there is no cheaper substitute in sight, there are good grounds for believing that, for the heavier forms of motor traffic, motor spirit may be replaced by much less expensive fuels. A certain amount of success has already been attained in the use of small suction-gas producers in the slower and heavier classes of motor vehicles. The best hopeful prospect in this direction appears to me to be based on the designing of small suction-gas producers for definite types of solid fuel. The inventor too often feels that the success of his invention will depend on its adaptability to a great variety of conditons; and he fails to make any one successful design by attempting to deal simultaneously with a number of variables.

Small suction-gas producers for motor vehicles ought, in the first instance, to be definitely designed for, and worked with one definite type of solid fuel. Anthracite, low-temperature coke, wood, charcoal, and peat charcoal, each have their special characteristics, which will affect the design and working of the gas producer. The more important features which must be taken into account are: Freedom from tarry or oily impurities, density, inflammability, and the quantity and nature of the mineral ash.

Before considering in more detail the role of carbonisation and gasification at various temperatures as a means of sorting out from raw coal solid, liquid, and gaseous forms of fuel, let us pass in review very broadly the uses to which the 139 million tons of coal are put which are consumed in the raw state.

We all take our share in the consumption of the 35 million tons of coal which are devoted to domestic use; and most of us have a kindly feeling for our old friend the open fire. The work of Dr. Margaret Fishenden on open fires has definitely shown that, under reasonable conditions of firing, 20 per cent of the total potential heat of the raw coal is radiated into the room, and that a further 20 to 30 per cent is given up to the fabric of the building before the waste products of combustion leave the chimney. Smoke and soot are, however, an unduly heavy price to pay for the transient cheerfulness of the flaming coals in a well-stoked fire, especially when we remember that over long periods the ordinary fire is only smouldering and dreary looking. The coal-fired kitchen range, unlike the open room fire, has few, if any, sentimental associations, and its replacement by gas-cookers and coke-fired water heaters is only a matter of time.

I have for many years taken a deep interest in the production of a solid smokeless fuel for domestic purposes by the carbonisation of selected coals at 550° to 600° C. The resulting coke is entirely free from smoke-producing hydrocarbons, while still containing 10 to 12 per cent of volatile combustible matter, which burns with a slightly luminous, perfectly smokeless flame. When the coke is kindled, it becomes enveloped by these flames, which quickly raise the surface to incandescence. Undoubtedly, if this smokeless solid fuel could be introduced at a cost permitting of its being sold at little more than the price of the coal which it would replace, it would lead to a complete revolution in domestic heating, and, among other good things, to the abolition of black smoke from house fires. This attractive prospect has been spread before our eyes for many years by enthusiastic inventors and company promoters, yet its realisation seems always to move a little further into the future.

The problem really has two distinct sides—the technical and the economic. On the economic side, the data for a final solution will only be obtained after the technical solution has been reached. In other words, until a fair-sized industrial plant has been carried on continuously over a long period, making and disposing of all the products of carbonisation under steady market conditions, no one can say whether or not the business will be a profitable one.

On the engineering side, an efficient and not too costly apparatus must be designed and constructed in the working of which manual labour, fuel consumption, and maintenance costs are all reduced to a minimum. In these respects—as well as in its output capacity on a given ground area—the apparatus must stand comparison with gas-retorts and oil-shale retorts of the most modern types. Only when this ideal has been practically realised can the future of low-temperature carbonisation as a business proposition be put to the test of continuous working on a large scale under the labour and market conditions of the day.

From the experience of the past two years at the Fuel Research Station with a considerable variety of coals, we know with certainty the yields and quality of the gas, oils, and coke produced under definite conditions; but this knowledge is only the first step in the inquiry. For, until we know with equal certainty the cost of producing these, and the markets in which they are to be disposed of, no economic balance-sheet of any real value can be arrived at.

Let me illustrate the market uncertainty by a few comparative figures. Assume that 15 gallons of fuel oil suitable for naval use can be obtained from a ton of coal. Six months ago the value of this oil could be safely taken at 1s. per gallon; and the 15 gallons would have realised 15s. To-day, the price of this oil is only 4d. per gallon; and the product would therefore only realise 5s.—a drop of 10s. per ton on the coal carbonised. It is obvious that a method of carbonising which would have paid its way handsomely six months ago would to-day result in a loss. My own belief is that low-temperature carbonisation can only be established on a sound commercial basis with low operating costs and a very moderate margin of profit.

Prior to 1914, the shale-oil industry in Scotland was distilling three million tons of shale per annum. The entire cost of the carbonising operation, for labour, maintenance, and fuel was 1s. 6d. per ton; and the margin of profit on which fair dividends were paid was 2s. 6d. per ton. Unless the costs and profit margins of low-temperature carbonisation can be reduced to the modern equivalents of these figures, the prospects of its development on a great scale are not hopeful, from the national point of view.

If low-temperature carbonisation is proved to be a feasible operation commercially, it would

find it first and most natural application to the 35 million tons of coal used for domestic purposes. Were this coal all carbonised, it would produce about two million tons of fuel oil for the Navy, or considerably more than the peace requirements, though very much less than the war requirements. The motor spirit produced would amount to about 100 million gallons.

The capital expenditure required for the installation of carbonising plant for 35 million tons of coal per annum would be of the order of 30 to 40 millions sterling. A gross profit of 5s. per ton of coal carbonised would provide 10 per cent for interest, and 10 per cent for depreciation on this expenditure.

The application of low-temperature carbonisation to raw coal which is used in the industries must necessarily depend on the successful solution of the technical and engineering problems to which reference has been made. In this case also, the future possibilities of this application depend entirely in the evolution of apparatus and methods which will reduce the capital and working charges of the operation to a minimum.

(To be continued).

NOTICES OF BOOKS.

An Introduction to the Chemistry of Plant Products. Vol. I. By PAUL HAAS, D.Sc., Ph.D., and T. G. HILL, A.R.C.S., F.L.S. Third Edition. Pp. xiii.+414. 1921. London: Longmans, Green & Co. Price 16s. net.

With this edition, the authors have divided their treatise into two volumes: Volume I., which is essentially the same in scope as the earlier editions, deals primarily with the chemical side of the subject; but a sufficiency of plant physiology has been retained to make the book complete in itself. Vol. II., which is in preparation, will be devoted more to purely physiological problems. The present volume has been brought up-to-date, some portions have been re-written, for example, Section viii., which deals with the colloids, has been enlarged upon. The book consists of ten sections, each section dealing with a group of plants belonging to the same chemical family; for instance, Section i. deals with fats, oils, and waxes; Section ii. with aldehydes; Section iii. with carbohydrates, &c. At the end of each section is given a short bibliography, to which the reader may turn for more detailed accounts of the subject under discussion.

Ammonia and the Nitrides. By E. B. MAXTED. Pp. viii.+116. 1921. London: J. & A. Churchill & Co. Price, 7s. 6d.

In this small volume, the author briefly describes the researches of Haber, Le Rossignol, and others, on the synthesis of ammonia and the conditions which govern the equilibrium point, together with his own work on the synthesis of ammonia at very high temperatures. The results are carefully tabulated, and a clearly-written account of the experiments made, with good diagrams of the apparatus used, combine to make this section valuable alike to research workers and to students.

The second portion of the book, dealing with that little-known class of compounds—the nitrides—contains first an account of the general methods of preparation and properties of these bodies, followed by a short description of each one which has so far been obtained. The book concludes with a chapter on the work of Strutt, and the more recent work of Tiede and Domcke on the preparation, properties, and probable constitution of active nitrogen. All the information given is of the latest and most up-to-date character, and the book is both interesting and valuable to read.

CHEMICAL NOTICES FROM FOREIGN SOURCES.

Comptes Rendus Hebdomadaires des Séances de l'Academie des Sciences. Vol. clxxiii., No. 5.

"The System Bromine-Tellurium. Nature of Tellurium Sub-bromide."—By M. A. Damiens.

"Preparation of Acyclic δ-diketones."—By M. E. E. Blaise.

NOTES.

BOARD OF TRADE ANNOUNCEMENT.—The attention of British subjects resident in this country who have pre-war debts owing to them from branches outside Germany of German undertakings whose head office is in Germany, is drawn to the fact that apart from their remedy against the branch, they may be entitled to claim payment alternatively from the head office through the Enemy Debts Clearing Office. In the event of there being any doubt as to the recovery of such debts from the branch, British creditors will be well advised to file a claim aganst th ehead office with the Enemy Debts Clearing Office, Cornwall House, London, S.E.1. It is essential, however, that any such claims should be received by the Clearing Office before September 30.

THE *Manchester Guardian Commercial* says that as a sequel to the recent visit to this country of a delegation of American and Canadian dry goods merchants, it is proposed to set up a commercial entente between this country and America and the British Dominions. "I understand," says the London correspondent of this journal, "that it will be the business of the joint committee to set up a sort of clearing house of information between traders in the various countries who come into the scheme, whereby the interests of them all will be looked after in the various territories. Another feature of the scheme will be the arrangement of exchange visits to and from America and the Dominions of the sons and proteges of commercial men for the purpose of gaining for them wider business experience. Ultimately it is proposed to enlarge the scope of the undertaking by including other foreign textile organisations."

TUNGSTEN CRYSTAL WIRE AS GLOW LAMP FILAMENT.—O. Ely, in *Ver. deutsch. Ing. Zeitschr.*, 1918, lxii., 15-20. Abstract by Th. Verheggen in *Chem. Abstracts*, Feb. 20, 1919, xiii., 286-287.—After a brief historical review of the first metallic filament used in electric incandescent lamps, the different methods of manufacturing filaments for tungsten lamps are stated. The author then describes at length a new patented process (Julius Pintsch & Co., Berlin) for the manufacture of fila-

ments made of a long crystal of metallic tungsten. "Manufacture of tungsten crystal wire: The WO_3 is pulverised as finely as possible, and is completely reduced by heating in a hydrogen atmosphere to produce pure tungsten metal, a brilliant black-brownish metallic powder. To this tungsten is added a carefully determined quantity of ThO_2 (and) finally a colloidal binding material is added in very small quantities. From this doughy mass filaments of various diameters are formed. . . . After the extruded "threads" have been dried at a moderate temperature, they are placed, eight at a time, into the treating apparatus, where the transformation into pure metallic crystals takes place. The treating apparatus consists essentially of a glass cylinder closed at both ends and provided with two contacts joined by a helix of heavy tungsten wire. The filaments to be treated are poassed through the axis of this glowing helix by means of a simple mechanism; during the operation . . . the filaments to be treated are raised rapidly to a temperature of 2600°-2700°. A continuous current of reducing gas passes through the glass cylinder. . . . The speed of movement through the hot zone must be less than the speed of crystallisation in order to allow the crystals to grow gradually at the expense of the small adjacent crystals. If the linear velocity of the filaments passing through the helix is too great a very fragile filament composed of several crystals is obtained . . . that breaks at the interfaces of the successive crystals. Filaments composed of a single tungsten crystal, unlike some drawn filaments, retain all their ductility and softness and resist vibration and shock even after many hours of burning; which is not the case with some drawn filaments. Comparative tests made under the same conditions with a lamp provided with a Pintsch tungsten crystal filament and lamp provided with a drawn tungsten filament have shown that after a life of 1200 hours, the filament made of a tungsten crystal had not given rise to the slightest trace of deposit on the walls of the bulb, whereas the filament of drawn wire was more or less disintegrated." Numerous photomicrographs of the new filaments and some of the old-fashioned filaments are shown.

HOP-GROWING EXPERIMENTS IN SOUTH AFRICA. —During 1920, 4,077cwt. of hops, valued at £68,047, were imported into the Union of South Africa for beer-making, and the average quantity imported annually during the previous five years was well over 4,000cwt., principally from the United Kingdom, the United States, and Australia. With a view to supplying the Union's requirements of this article, hop sets have been imported from time to time for purpose of experiment, and as far as experience goes, states the *Journal* of the Department of Agriculture of the Union of South Africa, it is found that the District of George, with its climate and conditions similar to those found in parts of Europe where hop-growing prevails, gives promise of being the most suitable part of the Union for this purpose; indeed, it is recorded that nearly a hundred years ago a successful experiment with hops was carried out in the town of George. The present experiments at George were started in 1918, and are now under the supervision of the botanist at the Elsenburg School of Agriculture. The object in view is to demonstrate that a sufficient return of green hops per acre can be obtained to make the cultivation of the crop an economic success. A good yield of dried hops is estimated at anything from 10cwt. per acre upwards; at George the drying process accounts for 65 to 75 per cent of the weight of the green crop, the average showing that about 100lb. of green hops yield 30lb. dry weight. Thus far, some of the sections in the experiments at George have shown returns from two-year-old plants of from 7 to 8cwt. per acre; these plants should be in full bearing next season, when it is hoped that improved yields and more reliable returns will be obtained. An account has been kept of the cost of production, and, while this presents difficulties when combined with experimental work, it is estimated that, apart from the wages of the foreman, the cost of production (1919-20) was approximately from £45 to £50 per acre. A yield of about 8 to 10cwt. of dried hops may be expected, and at (say) 3s. 6d. per lb. (£19 12s. per 112lb.) in South Africa, it would seem that from an economic point of view the prospects of remunerative hop-growing in well selected localities are worthy of consideration. There are still various points which will need to be investigated, and while it may now definitely be stated that hops can be grown satisfactorily in one part of South Africa, at any rate it is emphasised that the fringe only of what may possibly develop into a stable industry has been touched.

TITANIUM PEROXIDE.—Treatment of titanium sulphate with hydrogen peroxide gives a yellow solution, a base of which precipitates an amorphous yellow powder, TiO_3. In preparing the double sulphate of titanium and potassium, M. M. Billy separated the hydrate of peroxide and noted that all analogous bodies regarded as salts of the oxide TiO_3 are compounds of hydrogen peroxide and perititanic salts corresponding to the peroxide Ti_2O_5.—*Comptes Rendus*, 1921.

BIOCHEMICAL PROCESS TO DETECT GLUCOSE.— The method of Bourquelot and Bridel is based upon the property of the emulsine to combine in an alcoholic medium, the sugar with the alcohol in which it is suspended. They endeavoured to apply the process to the study of plants and were thus able to obtain a characteristic β-methylgulcoside, the rotary power of which is easily determined and which, if in too small quantity, can be clearly seen under the microscope owng to the shape of its crystals.—*Comptes Rendus*, 1921.

ESSENCE OF JASMINE.—The flower of the jasmine is treated, in industry, to extract the perfume, by two very different methods, viz., that with volatile solvents (petroleum ether, rarely benzine), and secondly enfleurage, for which cold animal fats are utilised. Perfume manufacturers having noted since the employment of volatile solvents that the method styled enfleurage with cold animal fats gave a greater yield of perfume than with petroleum ether, M. Passy gives an explanation of this by the fact that in enfleurage the flowers continue to produce perfume owing to the vital activity of the cells and the quantity produced is only limited by survival of the flower. Thus, if it is killed by immersion in ether only, the perfume existing in the flower is obtained and production ceases with stoppage of the vital phenomenon. M. Passy proposes a method of enfleurage which consists in immersing the flowers

in water for a certain time. He extracted the essence by exhausting the water with ether. Resuming this idea, in a remarkable work, Mr. Hesse found that the yield from the jasmine in essence is five times greater with enfleurage than with volatile solvents. As the chemical composition of the essences obtained by the two processes is different, he supposes that there is a formation of odourous matter by decomposition of certain compounds, perhaps glucosides. Generalising this idea, Messrs. Charabot and Gatin regard it as a real chemical equilibrium: glucoside+water⇌glucose+essence. With this supposed decomposition of glucosides, the yield of essence could be increased by treating the jasmine flower so as to hydrolyse the glucoside or glucosides before extraction with petroleum ether. Experiment has demonstrated this to be so. — *Industrie Chimique*, June, 1921.

QUICKLY DRYING VARNISHES.—During the war, varnishes were utilised, which dried very rapidly (*Chem. Umschau in Neustr. Erfahr. und Erfind*, 1921, xxxviii., 3, 42). They were first made with *wood oil and very high percentage of volatile* solvents. They did not, however, dry quickly enough, and solutions of gum-lac were adopted (alcohol varnish). These also dried too slowly, and solutions of acetylcellulose were tried. For example, on can dissolve 550 grms. of cetylcellulose in 10 litres of a mixture of 60 parts methyl acetate, 10 methylethylcetone, 15 benzol, 10 acetone, 5 acetimic alcohol. To this solution 65 grms. of triphenyl phosphate are added, and sometimes small mixtures of phenyl acetate, *benzyl benzoate, and urea. To make the* varnish more elastic, 5 to 7 parts of castor oil are added, but the time of drying was increased. These varnishes were not used for airships, but gave washable coats for domestic work, especially on wooden partitions and wood floors. They were also employed as excipients for aluminium or zinc powder in metallic paints. They can be applied at a low temperature, and resist humidity. In many cases they are as good as oil varnishes.

NEW COMPANIES.

The under-mentioned particulars of New Companies recently registered are taken from the Daily Register compiled by JORDAN & SONS, LIMITED, Company Registration Agents, Chancery Lane, W.C.2.

E. R. CHERRETT, LIMITED.—(176157)—Registered August 8th, *1921. 18, Church Street, Monkwearmouth, Sunderland.* To acquire and carry on the business of Chemists and Druggists. Nominal Capital: £3,000 in 3,000 Shares of £1 each. Directors: E. R. Cherrett, 6, Glenthorpe Avenue, Roker, Sunderland; N. Jackson, 8, Campbell Terrace, Fulwell, Sunderland. Qualification of Directors: 100 Shares. *Remuneration of Directors: E. R. Cherrett* £7 10s. per week; N. Jackson £5 10s.

L. DENNIS & CO., LIMITED.—(176182)—Registered August 9th, 1921. To carry on the business of Manufacturers of all kinds of Chemicals and Allied Products. Nominal Capital: £15,000 in 10,000 Preference Shares and 5,000 Ordinary Shares of £1 each. Directors: To be appointed by Subscribers. Qualification of Directors: £500. Remuneration of Directors: To be voted by Company in General Meeting. Subscribers: L. Dennis, 26, Rutland Road, Walkden (Chemist): Kathleen Dennis, 26, Rutland Road, Walkden; W. Bannister, 19, Lawrence Road, Gledholt, Huddersfield.

P.L.A.C., LIMITED.—(176228)—Registered August 11th, 1921. 15, Walbrook, E.C.4. To acquire from Richard Pearson a process or the treatment of *Acaroid Resins and the* business of Manufacturing Acaroid Resins Lac. Nominal Capital: £400 in 400 Shares of £1 each. Directors: To be appointed by Subscribers. Qualification f Directors: 5 Shares. Remuneration of Directors: To be voted y Company in General Meeting.

New Patents.

THIS List is specially compiled for the *Chemical News* by Messrs. Rayner & Co, Registered Patent Agents, of 5, Chancery Lane, London, W.C.2., from whom all information relating to Patents, Trade Marks and Designs can be obtained gratuitously.

Latest Patent Applications.

20661—Bourcet, P.—Carburant for alcohol August 3.
20758—Klages, A.—Process for production of aromatic cyan mercury compounds substituted in the core. August 4.
20938—Pickard, H. F. K.—Treatment of ores containing oxidized copper compounds. August 6.
20570—Reid, J. H.—Reduction of ore and production of gas. Aug. 2.
20706—Ros, D.—Treating metallic sulphides. August 2.
20583—Schuphans, G.—Method of producing chemically-pure hydrochloric acid. August 2.

Specifications published this Week.

140784—Soc. anon—Produits Chemiques—Process for the production of acetaldehyde from acetylene.
166961—Clayton, T. A.—Sulphur-burning furnaces.
167066—Imray, O.—Manufacture of aralkyl esters of 2 phenylquinonline-4-carboxylic acid.

Abstract Published this Week.

Phthalic Acid and Anhydride.—Patent No. 164,785.—Messrs. The *British Dyestuffs Corporation has obtained a Patent for an improved* process for obtaining phthalic acid or its anhydride by treating naphthalene vapour with air or other oxygen-containing gas in the presence of a small amount of vanadyl chloride at 300-650° C. The mixture of naphthalene vapour, air, and vanadyl chloride vapour is passed through a vessel or tube, empty or containing pumice, firebrick, kieselguhr, etc., and the products condensed in cooling chambers. In plate of naphthalene other volatile hydrocarbons or their derivatives yielding phthalic acid on oxidation, such as a- or B-methylnaphthalene, tetrahydronaphthalene, a-naphthol, or o-xylene, may be used.

Messrs. Rayner & Co., will obtain printed copies of the published specifications and will forward on post free for the official price of 1/- each.

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AN ANALYSIS OF MOLECULAR VOLUMES FROM THE POINT OF VIEW OF THE LEWIS-LANGMUIR THEORY OF MOLECULAR STRUCTURE.*

By ROBERT N. PEASE.

ACCORDING to the Lewis-Langmuir theory of valence and atomic and molecular structure (Lewis, *Journ. Am. Chem. Soc.*, 1916, xxxviii., 762; Langmuir, *ibid.*, 1919, xli., 868), the numbers of electrons surrounding the positive nuclei of the atoms of the inert gases are such as to permit of particularly stable arrangements. The atoms of the other elements enter into combination in such a manner as to group around their respective nuclei, by taking up, losing, or sharing electrons, a number of electrons equal to that in the atoms of the inert gas nearest to them in the periodic table. (It is not to the particular arrangements of electrons in the inert gases that the atoms of the other elements tend to revert, for in organic compounds, for example, the carbon atoms are assumed to have the 8 electrons arranged in pairs at the corners of a tetrahedron, while in neon, the corresponding rare gas, the 8 electrons are at the corners of a cube). As a result of this tendency, the number of electrons about the positive nuclei of atoms of those elements which tend to revert to the *same* rare gas is the same, when the atoms are in combination. Further, it sometimes happens that different atoms or groups of atoms, existing alone as molecules or acting as the nuclear atoms of compounds, have as a whole the same numbers and *arrangements* (this is always to be undestood to refer to all the electrons in the molecule or group of atoms, not merely to those in the outer shell) of electrons, and therefore differ only in the magnitude and distribution of the charges on the positive nuclei of the atoms. Such compounds and groups of atoms Langmuir (Langmuir, *Jour. Am. Chem. Soc.*, 1919, xli., 1543) calls "isosteres." Langmuir has pointed out the marked similarity of physical properties of pairs of isosteres which are capable of independent existence as molecules, such as nitrous oxide and carbon dioxide. This being the case, it does not seem improbable that the volumes of isosteric atoms or groups of atoms, whether these exist as free molecules or as the nuclear atoms of a compound, may be the same. This involves the assumption that the outer shells of electrons in isosteres have the same dimensions independent of the charges on the positive nuclei of the atoms or at least that the volume of the molecule as a whole shall behave as if this were the case (see note, *prox.*). The remainder of this paper is devoted to establishing the fundamental correctness of this assumption, and to examining the evidence furnished by molecular volumes regarding the structure of certain molecules and nuclear atoms.

For the comparisons of molecular volumes the values of the quantity b of van der Waal's equation have been employed. These have been calculated from the relation $b = {}^1/_8 RT_c/p_c = 0·000458\ T_c/p_c$ in which, T_c is the critical temperature in degrees, absolute; and p_c is the critical pressure in atmospheres. The values of the critical temperature and pressure and of b are given in Table I. The results of Young and the recent determinations of Cardoso have been used wherever possible.

TABLE I.—*The values of Critical Temperatures and Pressures, and of van der Waal's b.*

T_c = critical temperature in degrees, Kelvin.
p_c = critical pressure in atmospheres.
$b \times 10^6 = 45·8\ T_c/p_c$.

	T_c °K	P_c Atmospheres	$b \times 10^5$	Observers
Ne	44·7	26·9	70	14
Ar	150·7	48·0	144	8
Kr	210·5	54·3	177	17
Xe	289·7	58·2	228	15
H_2	33·2	12·8	119	14
CH_4	190·2	45·6	191	7
NH_3	406·0	112·3	165	6
H_2O	647·0	217·5	136	10
C_2H_4	282·6	50·7	225	6
O_2	155·0	49·3	144	7
C_2H_2	308·6	61·7	229	6
N_2	128·3	33·7	174	7
CO	134·4	34·6	178	7
NO	180·2	64·6	128	1
CO_2	304·0	72·9	191	6
N_2O	309·6	71·7	198	6
PH_3	324·4	64·5	230	4
H_2S	373·4	89·1	192	6
HCl	324·4	81·6	182	6
C_2H_6	305·2	48·9	286	6
C_3H_8	370	44·0	385	[illegible]
n-C_5H_{12}	470·3	33·0	652	[illegible]
iso-C_5H_{12}	460·9	32·9	641	[illegible]
n-C_6H_{14}	507·9	29·6	785	[illegible]
n-C_7H_{16}	539·9	26·9	919	[illegible]
n-C_8H_{18}	569·3	24·6	1057	[illegible]
$(CH_3)_2CH.CH(CH_3)_2$	500·5	30·7	745	[illegible]
$(CH_3)_2CHCH_2CH_2CH(CH_3)_2$	549·9	24·6	1025	[illegible]
$(CH_3)_2O$	400·1	53·0	346	[illegible]
$(C_2H_5)_2O$	466·9	35·6	600	[illegible]
$C_2H_5NH_2$	456·2	55·5	376	[illegible]
$(CH_3)_2NH$	437·6	52·4	382	[illegible]
$(C_2H_5)_2NH$	496·3	36·6	621	[illegible]
Cl_2	414·0	83·9	226	[illegible]
	419·0	93·5	205	1
	417·0	76·1	252	[illegible]
CCl_4	556·2	45·0	566	[illegible]
$GeCl_4$	550·0	38·0	663	[illegible]
$SnCl_4$	591·8	37·0	733	[illegible]
C_6H_6	561·6	47·9	537	[illegible]
C_6H_{12}	553·1	39·8	635	[illegible]
$C_6H_5CH_3$	593·7	41·6	653	
C_6H_5F	559·6	44·6	574	[illegible]
C_6H_5Cl	632·3	44·6	648	[illegible]
C_6H_5Br	670·0	44·6	687*a*	[illegible]
C_6H_5I	721·0	44·6	740*a*	

a Calculated by Young.

1. Adwentowski, *Ion*, 1910, ii., 1; cf. *C.A.* 1910, iv., 2777.
2. Altschuel, *Z. physik. Chem.*, 1893, xi., 577
3. Berthoud, *J. chim. phys.*, 1917, xv., 3.
4. Briner, *ibid.*, 1906, iv., 476.
5. Briner and Cardoso, *ibid.*, 1908, vi., 641.
6. Cardoso, *J. chim. phys.*, 1912, x., 470.
7. Cardoso, *ibid.*, 1915, xiii., 312.

* From *Journal of American Chemical Society*, May, 1921.

8. Crommelin, *Comm. Phys. Lab. Leiden*, 1910, cxv., 118.
9. Dewar, *Phil. Mag.*, 1884, [5] xviii., 210.
10. Holborn and Baumann, *Ann. Phys.*, 1910, [4] xxxi., 945.
11. Kneitsch, *Ann.*, 1890, cclix., 100.
12. Nilson and Pettersson, *Z. physik. Chem.*, 1887, i., 38.
13. Olszewski, *Phil. Mag.*, 1895, [5] xxxix., 188.
14. Onnes, *Proc. Acad. Sci. Amsterdam*, 1917, xx., 178.
15. Patterson, Cripps, and Whytlaw Gray, *Proc. Roy. Soc.*, [A], 1912, lxxxvi., 579.
16. Pellaton, *J. chim. phys.*, 1915, xiii., 426.
17. Ramsay and Travers, *Phil. Trans. Roy. Soc.*, 1901, cxcvii., 47.
18. Young, *Sci. Proc. Roy. Dublin Soc.*, 1909-10, N.S. xii., 374.

Unfortunately, lack of space does not permit an extended discussion of the recent paper of J. J. Van Laar (Van Laar, *J. chim. phys.*, 1916, xiv., 3) on the addivity of the quantity *b* of van der Waal's equation. He has assumed arbitrary and sometimes variable values for the volumes of the atoms and obtains good average agreement between calculated and observed values. His atomic volumes are, however, difficult to reconcile with the Lewis-Langmuir theory.

The paragraphs immediately following deal with the molecular volumes of those compounds which contain carbon, nitrogen, and oxygen as nuclear atoms.

Methane, Ammonia, and Water.—The nuclear carbon, nitrogen, and oxygen atoms in methane, ammonia, and water respectively, are isosteric, since each consists of a positive nucleus and pair of electrons surrounded by an octet of electrons. If these isosteric nuclear atoms have the same volume, then the differences in volume between pairs of these substances will be the volume of the extra hydrogen atoms one contains over the other. The volumes of the compounds are: methane, 191; ammonia, 165; water, 136. Methane has one more hydrogen than ammonia, and is greater by 26 units. Ammonia has one more hydrogen than water, and is greater by 29 units. It should be remembered that the errors in the volumes fall on these differences. Taking the average difference of 28 as the volume of one hydrogen atom in these compounds, and subtracting for the total number of hydrogen atoms from the volume of each compound, to find the volumes of the nuclear atoms, one obtains for the latter the values

CH_4 : 191-112 = 79
NH_3 : 165-84 = 81 Average 80.
H_2O : 136-56 = 80

The nuclear atoms are seen to have almost exactly equal volumes, substantiating the assumption made.

For neon, the corresponding inert gas, the volume is 76. That the volume of the nuclear atoms in the above compounds is practically the same (80) would seem to indicate that these atoms are essentially cubic, as neon is assumed to be. The tendency of the hydrogen atoms to draw together the pairs of electrons, by means of which they are held, to give the nuclear atom a tetrahedral structure, is apparently not great. That the volume of the nuclear atoms and that of neon are not more nearly equal may be due to slight deformation of the cubic structures in the hydrides or to the inaccuracy of the value for neon, the critical data for which are given by Kammerlingh Onnes as preliminary.

Ethylene and Oxygen.—Elementary oxygen and the carbon atoms in ethylene are isosteric. In both, the positive nuclei (with a pair of electrons each)are surrounded by 12 electrons forming two tetrahedral octets sharing two pairs, that is, meeting along an edge. If the volumes of the two isosteres are the same, the difference in volume between ethylene (255) and oxygen (144) represents the volume of the four hydrogen atoms in ethylene. One-fourth of this difference should be the volume of one hydrogen.

$$\frac{V_{C_2H_4} - V_{O_2}}{4} = \frac{255 - 144}{4} = 28$$

The volume of one hydrogen is found to be 28 as in methane and the like.

Acetylene, Nitrogen, and Carbon Monoxide.—For reasons to be discussed later, nitrogen and carbon monoxide are assumed to have the normal, acetylenic, arather than the condensed structure suggested by Langmuir. Thus, nitrogen, carbon monoxide, and the carbon atoms of acetylene are isosteric, since the structure for all consists of two positive nuclei (with a pair of electrons each) surrounded by two tetrahedral octets composed of 10 electrons, three pairs being shared, that is, meeting face to face.

The volumes of nitrogen and carbon monoxide are 174 and 178, respectively, that of the unsymmetrical carbon monoxide being slightly the greater. Taking symmetrical nitrogen to compare with the symmetrical carbon atoms of acetylene (229), it is found that one-half the difference between the volumes of the two compounds, which should equal the volume of one hydrogen atom, is again 28.

$$\frac{V_{C_2H_2} - V_{N_2}}{2} = \frac{229 - 174}{2} = 28$$

It is convenient to point out here that the volumes of carbon dioxide and nitrous oxide, which are isosteric, are 191 and 198 respectively. If nitrous oxide has the structure N=N=O, as Langmuir is inclined to think, then again the unsymmetrical isostere (N_2O) has slightly the greater volume, as found in comparing carbon monoxide and nitrogen. The lack of symmetry in both cases is in the distribution of positive charge among the nuclei of the atoms.

Elementary fluorine is isosteric with the nuclear carbon atoms of ethane. As, however, the critical constants of the former have not been determined, no comparison can be made. It will be of interest to obtain a value for two tetrahedral neon octets sharing one pair, as in ethane. This can be done by subtracting 6×28 for 6 hydrogens from the value for ethane (286); thus 286−168=118 for the nuclear C—C atoms.

Summary.—From the above it results that with one value (28) for hydrogen, 80 for the cubic neon structure, 144 for two tetrahedral neon structures sharing two pairs and 174 when sharing three pairs, the volumes of methane, ammonia, water, ethylene, acetylene, carbon monoxide, oxygen and nitrogen can be reproduced as follows.

	Observed.	Calculated.	Δ	Van Laar calc.	Δ
CH_4 ...	191	192	+1	156	−35
NH_3 ...	165	164	−1	162	−3
H_2O ...	136	136	0	138	+2
O_2	144	(144)*a*	...	140	−4
C_2H_4 ...	255	256	+1	256	−1
N_2	174	(174)*a*	...	170	−4
C_2H_2 ...	229	230	+1	228	−1
CO ...	178	174	−4	170	−8

a Assumed in the calculation.

The calculated values agree with the observed within 0·5 per cent with the exception of that for carbon monoxide, which is about 2 per cent too low.

The results obtained in the foregoing analysis are taken to be good evidence of the correctness of the assumption that isosteres, whether existing alone as molecules or forming the nuclear atoms *of hydrides have the same volume, independent* of the particular atoms involved. It is very unlikely that all the relations cited above—namely, that the volumes of methane, ammonia, and water can be expressed with one value for all the nuclear atoms and another for hydrogen, or that this same value for hydrogen and the values for elementary oxygen and nitrogen can express the volumes of ethylene and acetylene, respectively—are simply fortuitous. It is true that Van Laar, making different assumptions, finds nearly as good agreement, with the exception of his value for methane, which is seriously in error (156 calculated; 191 observed). In order to get this agreement, however, he requires two values for hydrogen, two for nitrogen, and one each for carbon and oxygen. In the present analysis, one value is used for hydrogen, and three different values are assigned to the three different arrangements of electrons about the neuclear atoms met with in these compounds.

Effect of Multiple Bonds.—For ethane, ethylene, and acetylene, Van Laar uses a single value each for carbon and hydrogen, in effect assuming that the differences in volume among these compounds depend wholly upon the number of hydrogen atoms in the different molecules. The results recorded in this paper indicate that there is, in addition, a difference due to the manner in which the carbon atoms are combined, that is to say, a difference due to the type of electron structure. Expressed in terms of the volume of a single atom, the values for a single neon octet combined in the various ways are: sharing no pairs (CH_4, etc.) 80; sharing one pair (C_2H_6) 59 (118/2); sharing two pairs (O_2 and C_2H_4) 72 (144/2); sharing three pairs (N_2 and C_2H_2) 87 (174/2).

When one pair is shared, the volume is one-quarter less (59/80=74 per cent) than when no pairs are shared. The similarity between the volumes of the nuclear atoms in methane, &c. (when no pairs are shared with other octets) and that of neon was taken to indicate that the nuclear atoms in the former are nearly cubic. In ethane, *the nuclear atoms are almost certainly tetrahedral.* The ratio of the volumes probably represents, therefore, the relation between the volumes of the cubic octet and the tetrahedral octet of neon.

When two pairs are shared, the volume of a single atom is 13 units greater than when one pair is shared, and when three pairs are shared, there is a further increase of 15 unts per atom. The distances between the centres of two tetrahedra meeting (*a*) at their apexes (*b*) along an edge (*c*) at a face, are in the ratio, 4 : 3 : 2. These configurations correspond to the sharing of one, two, and three pairs, respectively. Thus, the tendency if unresisted, on sharing two and three pairs would be to bring the positive nuclei at the centres of the tetrahedral electron shells nearer and nearer together. The volume increases on sharing successively the second and third pairs represent the reaction of the positive nuclei against this tendency. By attempting to get as far apart as possible, they distend the molecule. This state of tension due to the multiple bond is evidently an element of weakness and the multiple bond might be expected to be a seat of chemical *activity, as is known to be the case.*

Structure of Nitrogen.—Langmuir accounts for the inertness of nitrogen and carbon monoxide by assuming a condensed *structure consisting of the* two positive nuclei each holding a pair of electrons (correspondng to helium) and holding between them a third pair, this structure being surrounded by eight electrons at the corners of a cube. The alternative structure consists of two octets sharing three pairs, as do the carbon atoms in acetylene. As the reactivities of nitrogen and *carbon monoxide are not so great as that of acety*lene, Langmuir is inclined to think the structures cannot be similar. Reactivity is, however, a rather vague term. It is true that nitrogen is commonly spoken of as inert, and acetylene as active chemically. Yet if the strength of the bond joining the the nuclear atoms be measured by the tendency of the two compounds to dissociate, the one into nitrogen atoms and the other into CH radicals, the *stabilities* must certainly be assumed to be of the same order.

As pointed out in the first part of this paper, there is good evidence that the volumes of elementary nitrogen and the two carbon atoms of acetylene are the same, thus indicating a similarity in structure. Furthermore, one would expect such a very condensed structure as Langmuir suggests for nitrogen, the outermost electrons of which form only a single octet, to have a decidedly smaller volume than elementary oxygen, for example, the outer shell of which consists of two octets of electrons sharing two pairs; or of argon, which consists of a single positive nucleus (but with a positive charge of 18), a pair of electrons and two octets of electrons one outside the other. Actually, the volumes of elementary oxygen and of argon are both 144, while that of elementary nitrogen—174—is decidedly larger than either.

The fact that the volume of elementary nitrogen is greater than that of elementary oxygen also has a bearing on the general assumption made in this paper, that it is principally the particular arrangement of electrons rather than the charge on the *positive nuclei* which *determines* the volume of an atom or group of atoms. Since the positive nuclei of oxygen atoms posses a charge of +8, while that of the nitrogen atoms is +7, one might have expected that the greater repulsion between the larger nuclei of oxygen would have given to elementary oxygen the greater volume. That it is distinctly less in volume than is elementary nitrogen, with +7 positive nuclei, indicates that the volume is more influenced by other factors. The other apparent difference between *the compounds, according to the theory, being in*

the number and arrangement of the electrons—the limiting boundaries of the molecules—it is reasonable to refer the volume relation rather to this.

Nitric Oxide.—Nitric oxide is peculiar in having an odd number of electrons (15). It is thus intermediate between elementary nitrogen with 14, and elementary oxygen with 16 electrons. Langmuir has suggested that it may have essentially the structure which he assigns to elementary nitrogen, the extra, odd electron being "imprisoned in the octet comprising the shell." As this structure for nitrogen has been rendered doubtful by the preceding considerations it will be of interest to find what other structure is possible and what are the indications furnished by the volume of the substance.

The volume of nitric oxide is suprisingly small, 128, that of oxygen being 144, and nitrogen, 174. It is, in fact, actually nearer that of the carbon atoms in ethane (118). Nitric oxide contains one more electron than nitrogen, and it is possible that in the former the octets, like those in nitrogen, share three pairs, the odd electron being at the centre of the triangle formed by these three pairs, directly between the two positive nuclei and held in place by the attraction of the latter. The odd electron so placed would certainly tend to draw the nuclei together, lessening the distention of the molecule and making the volume of the molecule less than that of elementary nitrogen. Actually the volume is reduced nearly to the normal volume of two octets sharing a single pair as exemplified by the carbon atoms in ethane. In the latter case, the shared electron pair is also placed directly between the two positive nuclei.

The odd electron, place as suggested above, would certainly be held under rigid constraints. Lewis (*loc. cit.*), who would attribute colour in compounds to weakly-held electrons, has pointed out that of the substances containing an odd number of electrons, only nitric oxide is colourless, that it to say, all the electrons including the odd, are rigidly held.

Hydrocarbons, Amines, and Ethers.—There are a few hydrocarbons, amines, and ethers for which data are available whose chains of nuclear atoms are isosteric and should, therefore, have equal volumes. A comparison of the 5- and 3-atom chains is given below. The volumes of the chains have been obtained by subtracting 28 for each hydrogen atom from the volumes of the compounds. It should be borne in mind that this method throws all the experimental error on the volume of the chain.

5-Atom Chains.

	$b \times 10^5$. 28 H. Chain.
n-C_5H_{12}	652−336=316
$(C_2H_5)_2NH$	621−308=313
$(C_2H_5)_2O$	600−280=320

3-Atom Chains.

	$b \times 10$. 28 H. Chain.
C_3H_8	385−224=161
$C_2H_5NH_2$	370−196=180
$(CH_3)_2NH$	382−196=186
$(CH_3)_2O$	346−168=178

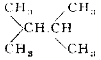
With the exception of the value obtained from propane, tbe agreement is satisfactory within each series.

Hydrocarbon Chains.—As is well-known, the volumes of compounds containing long chains of carbon atoms are not strictly additive. The values for the increment CH_2 usually rise in ascending a series. This is true of the values of *b* for the straight-chain hydrocarbons, as will be seen from the following comparison of observed values with those calculated from the values H=28 and C=59 (as found in ethane).

	Observed.	Calc.		Per cent.
C_2H_6	286	(286)	...	...
C_3H_8	385	401	16	4·2
n-C_5H_{12}	652	631	21	3·2
n-C_6H_{14}	785	746	39	5·0
n-C_7H_{16}	919	861	58	6·3
n-C_8H_{18}	1057	976	81	7·7
$(CH_3)_2CH.CH_2CH_3$ ...	641	631	10	1·6
$(CH_3)_2CH.CH(CH_3)_2$	745	746	1	0·1
$(CH_3)_2CH.CH_2CH_2$ $CH(CH_3)_2$	1025	976	49	4·8

For the straight chain compounds, the percentage by which the observed values exceed the calculated steadily increases, with increasing number of atoms.

The branched chain isomers have volumes smaller than the straight chain, and therefore nearer the calculated values. It is of interest to note that that compound in which the relative amount of departure from the straight chain is greatest, namely, di-*iso*-propyl,



has a volume almost identical with that calculated (745 observed; 746 calculated).

Ring Structures.—It is of interest to find what values are obtained for ring structures. The value for toluene will first be examned. The radical, C_6H_5, should have a volume equal to that of benzene less one hydrogen atom or $537-28=509$. The volume of CH_3 should be $59+(3\times 28)=143$. The sum of these gives the value for toluene, $C_6H_5CH_3$, 652. The observed value is 653.

For the rings in benzene and cyclohexane, the following values are obtained by subtracting for the total number of hydrogen atoms: C_6H_6, $537-(6\times 28)=369$; C_6H_{12}, $635-(12\times 28)=299$.

The unsaturated benzene ring has the greater volume. This is in agreement with the relations already found between the volumes of saturated and unsaturated nuclear atoms. The carbon atoms in cyclohexane might have been expected to have the volume 59 each. Actually the volume is $299/6=50$. The ring structure appears to be very much condensed.

Phosphine and Hydrogen Sulphide.—Data are not available for enough compounds having nuclear atoms related to argon, as those just discussed are related to neon, to allow very satisfactory comparisons to be made. There are dependable values for phosphine ,hydrogen sulphide and hydrogen chloride, however, and these will be analysed so far as possible.

If, as in the case of methane, ammonia, and water, the difference between the volumes of phosphine and hydrogen sulphide $(230-192=38)$ be taken as the volume of one hydrogen in these substances, then for the volume of the nuclear atoms, one obtains: PH_3, $230-(3\times 38)=116$; H_2S, $192-(2\times 38)=116$. Because of the method of treatment the value for the nuclear atom is necessarily the same in both cases. This value (116) is 116/144,

or 80 per cent of that of the corresponding rare gas, argon. A carbon atom in ethane sharing one pair (and in the tetrahedral form) has a volume 59/76, or 78 per cent of that of the corresponding cubical atom, neon. As the volumes of the nuclear atoms in phosphine and hydrogen sulphide bear nearly the same numerical relation to that of the corresponding cubic atom, argon, it would appear that already in the simple hydrides the nuclear atoms related to argon are tetrahedral. The hydrogen atoms by their attraction for pairs of electrons appear to have been able to deform the argon (cubic) structure to such an extent that it is essentially tetrahedral. As the volume of argon is nearly twice that of neon (144, 76) one might have expected this relatively greater deformation of the former structure.

Volume of Hydrogen.—The volume of hydrogen in these compounds appears to be greater than in those compounds containing nuclear atoms related to neon. This is undoubtedly the effect of the very much larger charge on the positive nuclei of atoms related to argon. The hydrogen atom in each of these compounds actually consists only of a singly charged positive nucleus of exceedingly small volume held by means of an electron pair of the nuclear atom but repelled by its positive nucleus. Its contribution to the volume therefore, depends on the equilibrium position it holds with respect to the electron pair and positive nucleus of the nuclear atom. If it is forced out, its apparent volume will be greater and *vice versa*. The hydrogen atom cannot be expected therefore, to have a constant volume. This is emphasised by the fact that in the elementary state ($b = 119 \times 10^{-5}$), the atom has the relatively very great volume of 60. The greater apparent volume of hydrogen in hydrogen sulphide as contrasted with that in water is indicative of the greater ease of ionisation of the former compound —the hydrogen nucleus is normally separated from the nuclear atom to a greater extent. It may be pointed out here that Van Laar's values of 14 for hydrogen combined with carbon and 34 for hydrogen combined with any other atom, are not so easily explained. Although carbon is a very peculiar element, it is not so markedly different from all other elements, on the basis of the theory, as to lead one to expect any such distinction between the volume of hydrogen associated with it and associated with any other element. One would rather expect either a different value for hydrogen combined with each element or compound, increasing with increasing atomic weight of the element or else for each rare gas type of nuclear atom, as apparently is the case. (It is possible that the apparent volume of the hydrogen atom does increase slightly as the charge on the positive nucleus of the nuclear atom increases, but that this is offset by the fact that the electron shell about the nuclear atom *decreases* slightly in volume with increasing nuclear change—the electrons are displaced inward somewhat. It is, in fact, possible to get slightly better agreement assuming a slight regular increase in volume for hydrogen and decrease in volume for the nuclear atom with increase in charge on the positive nucleus of the nuclear atom, in any given series).

Hydrogen Chloride.—The treament of the value for hydrogen chloride presents certain difficulties. One is prepared to find a structure rather different fro many of those so far considered, because of the strongly polar nature of the compound. The value (182) is clearly relatively greater than that of hydrogen sulphide, since with one less hydrogen, the value is only to less (192, 182). If 38, the value for hydrogen in phosphine and hydrogen sulphide be subtracted from the hydrogen chloride value, the remainder ($182 - 38 = 144$) is precisely the value of argon itself. The chlorine atom in hydrogen chloride thus appears to have the cubic structure, one hydrogen being insufficient to force the atom into the tetrahedral form. This is, of course, just the form (*i.e.*, cubic) which the halogen and alkali atoms are supposed to have in alkali halide crystals, the alkali halides being also highly polar. The assumption of the cubic argon structure by the chlorine atom in hydrogen chloride may serve in some degree to account for the difference in properties between hydrogen chloride and hydrogen sulphide.

Chlorine.—The various determinations of the critical constants for elementary chlorine are, unfortunately, widely divergent. The values for $b \times 10^{+5}$ are 226 (Dewar) 205 (Knietsch, 1890) and 252 (Pellaton, 1915), giving the values 113, 103, and 126 for one chlorine atom. Van Laar chooses to take Dewar's value (113), which is not far from that found here for the nuclear atoms in phosphine and hydrogen sulphide (116). The latter were assumed to be more nearly tetrahedral. Two octets sharing one pair with no combined hydrogen atoms may not be tetrahedral, however. Undoubtedly the attraction of the two positive nuclei will tend to draw the shared electrons toward the line joining the nuclei, thus deforming the cubic structure, and the volume of the molecule will at least be less than that of two cubic structures with volume 144 (argon) each. Pellaton's recent value of 126 for each atom in elementary chlorine seems best to fulfil the requirements, since it is midway between that of the tetrahedral atoms in phosphine and hydrogen sulphide (116), and that of the cubic atom, argon (144), corresponding to a deformed cube structure.

Atoms Similar to Krypton and Xenon.—It is not possible to make an analysis of the volumes of compounds containing nuclear atoms related to krypton and xenon, because critical data have only been determined for one or two. Since, according to Langmuir, the outer shell of these atoms is made up of 18 instead of 8 electrons, one cannot apply the results already arrived at to the examination of these few compounds. There are, however, two series of compounds the volumes of which yield interesting results. These are the tetrachlorides of carbon, germanium and tin and fluoro-, chloro-, bromo-, and iodobenzene.

The Tetrachlorides of Carbon, Germanium, and Tin.—If the carbon atom in carbon tetrachloride (566) be taken to be tetrahedral (59), as it almost certainly is, since it shares all four pairs, there is obtained for the volume of one chlorine $((566 - 59)/4 = 127)$. This is very close to Pellaton's recent value for one chlorine atom in elementary chlorine (126). If 127 be taken as the volume of one chlorine in germanium and tin tetrachlorides, one obtains for the volume of germanium and tin $GeCl_4$, $663 - 507 = 156 = Ge$; $SnCl_4$, $733 - 507 = 226 = Sn$. The volumes of the corresponding rare gases

are krypton, 177, and xenon, 228. The value for tin (226) is close to that of the corresponding rare gas, xenon (228), indicating that the shell of 18 electrons has not been greatly deformed. As the electrons are probably closer together than in the shell of chlorine, it is not impossible that the chlorine might be deformed cubic and the tin atom still have essentially the structure of the rare gas, xenon. The value for germanium (156) is somewhat less than that of the rare gas, krypton (177), to which it corresponds. This would seem to indicate some deformation. However, of the two, greater weight must be attached to the value for tin, since the constants for tin tetrachloride are those of Young, while the constants of germanium tetrachloride were determined by Nilson and Petterson (1887) and represent, so far as known, the only determinations of critical constants published by these authors.

A new determination of the critical constants of germanium tetrachloride and a determination of those of silicon tetrachloride would be of great value in this connection.

The Aromatic Halogen Compounds.—The value for benzene is 537. Subtracting 28 for one hydrogen, the value 537−28=509 is obtained for the phenyl radical, C_6H_6. If this value be subtracted from those of the aromatic halogen compounds, the remainder should be the volume of the halogens: C_6H_5F, 574−509=65=F; C_6H_5Cl, 648−509=139=Cl; C_6H_5Br, 687−509=178=Br; C_6H_5I, 740−509=231=I.

For fluorine, a value between 59 (tetrahedral) and 80 (cubic) was to have been expected. The value found is 65. For chlorine, the value 126 was looked for. Actually a value (139) somewhat nearer that of argon (144) was obtained. For bromine (178) and iodine (231), values close to those of the corresponding rare gases, krypton (177) and xenon (228) are obtained, as in the case of tin in tin tetrachloride. As bromine and iodine each share with the radical only one pair out of 18 electrons, one would certainly not expect any great deformation, and little apparently occurs.

Volumes of the Rare Gases.—According to Langmuir (*Jour. Am. Chem. Soc.*, 1919, xli., 932), "the electrons in *any given atom* are distributed through a series of concentric shells, all of equal thickness. Thus, the mean radii of the shells form an arithmetic series, 1, 2, 3, 4 . . . ." These shells contain two sets of electrons. Thus, in xenon, the first shell contains the two electrons corresponding to helium, the second shell contains the two octets of electrons corresponding to the outermost electrons of neon and argon, respectively, and the third shell contains the two sets of 18 electrons, one outside the other, corresponding to the outermost electrons of krypton, and finally, xenon itself. It is specifically stated that this relation of the radii of the shells holds only for one given atom. It will, however, be of interest to see if any such simple relation holds for different atoms.

If the radii are in the ratio 1 : 2 : 3, the mean volumes of the shells must be as 1 : 8 : 27. If the mean volume of a given shell is the same in every atom which contains it, then it might be expected that the mean of the volumes of neon and argon, representing the second shell (helium accounts for the first) and of krypton and xenon, representing the third shell, would be to each other as 8 : 27. The values actually obtained are (76+144)/2=110; and (177+228)/2=202·5. The mean of the volumes of neon and argon is 110, that of krypton and xenon, 202·5. These are clearly not in the ratio required. In krypton and xenon, it is quite possible that because of the larger charge on the positive nucleus, the electrons of the second shell will be drawn inward more than the corresponding electrons in neon and argon, and the mean volume of the shell be enough smaller than in neon and argon to satisfy the relation. (It is of interest to note that the volumes of the rare gases are roughly proportional to the square roots of their atomic weights, as will be seen from the following Table:—

	b	At. wt.	$\sqrt{\text{At. wt.}}$	$\frac{b}{\sqrt{\text{At. wt.}}}$
Ne	76	20	4·47	17·0
A	144	40	6·32	22·8
Kr	177	83	9·11	19·4
Xe	228	130	11·4	20·0

In fact, rough average agreement can be obtained for molecular volumes (in general) if they are assumed to be proportional to the sum of the square roots of the atomic weights of the constituent atoms).

Two facts in particular, are brought out by the foregoing analysis. First, isosteric atoms, molecules and groups appear to have the same volume regardless of the particular kinds of atoms of which they are composed. In other words, the number and arrangement of electrons in the outer shells of atoms or groups of atoms is the predominating factor in determining their volume. Second, the volumes of other atoms, particularly of the more complex ones, are intimately related to the volumes of the rare gases.

It is realised that the possibilities of the method of treatment used in this paper are by no means exhausted, and the writer expects at some future time to consider further the implications of the present work.

Summary.

1. An analysis of molecular volumes, as determined from the critical data, has been made from the point of view of the Lewis-Langmuir theory, and especially of Langmuir's theory of isosteres.

2. Evidence has been brought forward to show that isosteric molecules and nuclear atoms in hydrogen compounds have the same volume. The volume depends, therefore, on the number and arrangement of electrons surrounding the positive nuclei of the atoms rather than on the charges on the nuclei, that is to say, on the particular kinds of atoms concerned. Thus, it has been shown that the nuclear carbon, nitrogen, and oxygen atoms of methane, ammonia, and water, respectively, have the same volume.

3. It has been shown that the carbon atoms in ethane, ethylene, and acetylene have volumes increasing with the degree of unsaturation. The same observation holds in comparing the carbon atoms in benzene and cyclohexane. The volumes of atoms thus increase with the number of electron pairs shared. An explanation of this has been presented.

4. It has been shown that elementary nitrogen and carbon monoxide probably have the normal or acetylenic structure, three pairs being shared, rather than the condensed structure suggested by Langmuir.

5. A structure for nitric oxide has been suggested and evidence in its favour produced.

6. The volumes of the rare gases have been considered from the point of view of Langmuir.

The writer is especially indebted to Professors H. S. Taylor and Alan W. C. Menzies for criticism and suggestions regarding the work summarised in this paper.

THE BLEACHING OF SHELLAC.

By S. T. GADRE.

The action of sunlight can decolorise a solution of shellac as well as can animal charcoal. Shellac can also be deprived of its colour by pouring its alcoholic solution into potassium hypochlorite solution or by passing chlorine into a potash solution of shellac. But these methods do not find commercial application.

Theory of the Process.—Bleached shellac is prepared from ordinary shellac by the action of hypochlorite of soda on the alkaline solution for the purpose of removing the red-brown colour of the lac. The lac dye is bleached very quickly, but the yellow colour of the erythrolaccin is more persistent, and a greater or smaller quantity survives the bleaching entirely; hence the bleaching is due to the more or less complete destruction of the erythrolaccin.

Description of Process.—The method employed for bleaching shellac was as follows: 1lb. of soda ash was dissolved in 3 gallons of water and heated to boiling point in a circular wooden vat fitted with lead piping for steam heating. 5¼lb. of ground shellac (button lac) were then added slowly. The shellac dissolved in the alkaline solution, leaving only a small amount of suspended matter (impurities floating) on the surface. 5¼lb. of bleaching powder were then dissolved in 10½ gallons of water: to this mixture 4¼lb. of soda-ash were added. The whole was well stirred and filtered. The clear solution so obtained is sodium hypochlorite. This solution was then added to the hot shellac solution. The addition was effected gradually, and in small portions towards the end, with short intervals between the additions.

Characteristics of the Product Obtained.—The product obtained by bleaching shellac is white in appearance, and is rather crisp and brittle. Bleached shellac in the form of a dry powder is ready for immediate use for the preparation of shellac varnish, this variety being largely employed in the United States. Bleached shellac contains no wax but still contains water, and gradually undergoes a change into a modification insoluble in alcohol and alkalies. This change cannot be prevented. It will take place with greater ease at high temperatures. Bleached shellac should be used promptly. It dissolves in the same solvent as orange shellac; the solution is milky white, (the milkiness being due to the suspension of insoluble shellac wax. In alcoholic shellac solutions, the wax partly settles in time. Bleached shellac should be stored in as cool a place as possible, and should be kept under water. This precaution is necessary to avoid blocking of shellac in summer weather.

The samples of bleached shellac obtained in this laboratory were examined, firstly, with a sample of bleached shellac from England, and secondly, with a sample manufactured by Messrs. D. Waldie & Co., Konnagar. Table I. gives comparative results. The solubility figures show the enormous deterioration which bleached shellac undergoes on exposure to light and air:—

The materials used in the experiment analysed as follows:—

1. Button lac (shellac). Iodine value, 3·01 (by Wij's solution). (Allowable limit of iodine value for T.N. shellac, 14—17. Iodine value increases as perecentage of resin in shellac increases. Shows freedom from resin).
2. Soda-ash, 85 per cent Na_2CO_3.
3. Bleaching-powder contains 25 per cent available chlorine on an average.

Calculation of Costs of Experiments as carried out.

Shellac (button lac).	Rs.	a.	p.
5¼lb. at Rs.275 per maund	18	6	0
Soda-ash 5¼lb. at Rs.6-8-0 per cwt. ...	0	5	3
Bleaching-powder 5¼lb. at Rs.71 per cwt.	3	8	0
*Steam	Negligible		
Labour—one workman at 8 annas a day for an 8-hour day	0	8	0
	22	11	3
	Or, say, Rs.23		

* The very small amount of steam used is only a very minute fraction of that required in the works for pumping water and for other purposes.

Taking the yield of bleached shellac as 5¼lb. less 0·22lb., or 4 per cent less (3 per cent being lac wax and 1 per cent insoluble matter) or 5·28lb., the cost of production per lb. of bleached shellac works out at Rs.4-6-0. The cost will be very greatly reduced if the production of large quantities of bleached shellac is taken in hand, and also if cheap chlorine be made available in quantity.

TABLE I.

Sample of bleached shellac.	Colour.	Hardness.	Solibility in cold alcohol (62·5 per cent.)
*English make	White (very slightly dark at the core).	Very crisp	12·1 per cent soluble
**D. Waldie's make	Dark	Rather plastic	
†Our own make	White	Crisp	56·6 per cent soluble
‡Our own make	White	Rather plastic	Almost complete

* The sample had been kept in our laboratory for a long time.
** The shellac was stored under a slightly acid solution.
† Kept exposed to light and air for six months.
‡ Freshly made and kept under water for 15 days.

The calculation has been made with inflated prices of shellac and bleaching powder, such as are current at the present time. In 1903-4 the price of shellac rose to 230s. per cwt.; in 1908-9 the price was reduced to 60s. per cwt. Quite exceptional prices were reached during the war, even 400s. per cwt. being exceeded. In 1918, arrangements had been made in England by which the shellac required for munitions was obtained direct from India at 144s. 6d. per cwt. for all Government contractors who could produce evidence that they required the supplies for Government orders.

Composition of Bleached Shellac.—According to Tschirch, bleached shellac contains chlorine, so that the iodine absorption is materially modified. Fraymouth ("An Argument for a Change in the Lac Industry," Indian Munitions Board Industrial Handbook, 1919) says that an additive compound of shellac with chlorine is obtained.

This problem will shortly be taken up for investigation at the technical laboratory, since a few samples of bleached shellac made here did not on examination reveal the presence of chlorine.

Bleached Shellac: Its Preparation as a Local Industry.—Mr. Fraymouth says "it is unlikely that white lac will ever be manufactured in India, because it remains hard only at low temperatures." India is the great shellac-producing country of the world, and it should really be her monopoly to manufacture white lac (bleached shellac). If chlorine is rendered available in large quantities and as a cheap commodity, then there is absolutely no reason why India should not be the seat of manufacture of bleached shellac. The most vital drawback to its local manufacture is the scarcity of chlorine, or, for the matter of that, cheap chlorine.

White shellac is at present unknown and unobtainable in the country, and owing to its rapid deterioration, unless made into polish, is not imported. Several of the Indian timbers cannot be properly finished without the use of bleached shellac, and a considerable addition to the uses of certain woods is sure to follow if the matter of polish can be handled locally.—*Journal of Indian Industries and Labour.*

FUEL PROBLEMS OF THE FUTURE.*

By Sir George T. Beilby, F.R.S.

(Concluded from p. 118).

When coal is used for steam-raising under the best-known conditions, it is obvious that there is little to be gained in thermal efficiency by any preliminary sorting-out of the thermal units of the coal into fuels of higher availability. It is well-known that an efficiency of 75 to 80 per cent is attainable in steady practice. This is brought out by the results of the working during the first quarter of the present year at the two London power stations to which reference has already been made. At the station of the General Electric Supply Co., the average efficiency, less banking, was 75·5 per cent, though the average percentage of ash was 18·4. At the Durnford Road power house, the average efficiency was 78 per cent, and the average percentage of ash was 16. Supposing the coal used at these stations had been submitted to preliminary carbonisation and its thermal units sorted out into the forms of gas, tar, and coke, how would this have affected the evaporative efficiency of the total thermal units of the coal?

The coke would contain 70 per cent, the gas 12 per cent, the oils 11 per cent=93 per cent; intrinsic thermal loss 7 per cent, heat to be supplied for carbonisation 6 per cent=13 per cent; net thermal value of the products=80 per cent.

The high thermal availability of the rich gas would be thrown away if it were used for steam-raising; the fuel oil would be a boiler fuel decidedly superior to the original coal; and the coke would not be of more than equal value to the coal. Solely from the steam-raising point of view, therefore, a thermal loss would result, and not a gain, from the operation.

I at once admit that in special cases this thermal loss might be compensated for if a local market for the rich gas were available. In most cases, however, the margin of profit would be much too small to justify the extra capital expenditure required.

The valuable papers of Mr. D. Browlie (*Engineering*, July 12 and 19, 1918; July 25 and Aug. 1, 1919; Dec. 10 and 17, 1920) throw a much-needed light upon the use of coal for steam-raising. His analysis of the statistics which he has collected shows that the amount of coal used for steam generation in this country for heat and power production is from 75 to 100 million tons per annum, or about one-half of the whole coal consumption. Mr. Brownlie's conclusions as to the comparative efficiency of the numerous boiler plants he has personally examined during the past seven or eight years, and the extension of these conclusions to cover the whole steam-raising practice of the United Kingdom, supply us with material on which some broad generalisations may be based. Mr. Brownlie divides the existing boiler installations in the United Kingdom into three classes—bad, average, and highly efficient. Of the total number, 10 per cent are bad, 85 per cent are average, and 5 per cent are highly efficient. As regards the efficiencies of each class, with water-tube boilers, the bad give 61 per cent, the average give 69 per cent, and the highly efficient give 82 per cent; while with Lancashire boilers, the bad give 49 per cent, the average 60 per cent, and the highly efficient give 79 per cent.

If we take the minimum figure of 75 million tons as the amount of coal annually used for steam-raising, it is clear that the scope for economy is enormous; for even a moderate increase of efficiency of 10 per cent over all would result in a saving of 7½ million tons per annum. Mr. Brownlie's own experience of the savings to be effected by the reorganisation of existing plants leads him to take a much higher saving as a possibility. In the case of the colliery steam-boiler plants (the average efficiency of which he places at 51 per cent), he estimates that the coal bill for all the colliery plants in the country is 18¼ million tons, and that the efficffiiency might easily be raised by 10 to 15 per cent; while by the systematic use of colliery waste a further saving of saleahle coal would be realised.

Mr. Brownlie's facts and figures are well worth the careful study of all who are seriously interested in fuel economy. These show the enor-

*Delivered in the theatre of the Institution of Civil Engineers, London. Inserted by favour of the *Gas Journal*, June 29, 1921.

mous possibilities in this direction which are actually within our grasp if we will only avail ourselves of the knowledge which already exists. No new and revolutionary discoveries are required for their realisation. The problem of the future which awaits solution is how to stimulate the practical interest of the owners of steam-raising plant throughout the country. It may be that the permanently increased cost of coal will supply the necessary stimulus· but this will only begin to take effect when the industry has settled down to more normal conditions. For steam-raising in this country, the cheapest form of fuel is coal or coke, if it is used under reasonably scientific conditions; and so long as this is the case, the use of fuels of higher availability will only be economically practicable under very special conditions.

In America the use of pulverised fuel is making steady progress, not only for metallurgical purposes (for some of which it is very suitable), but even for steam-raising. The case for steam-raising by this method is still, however, by no means clear.

The primary object of the coke industry is the production of hard coke for the manufacture of iron and steel. The coals must be of a special type. The therms obtained in the form of gas, *though of high availability, are primarily used for* the heating of the coke-ovens, for which therms of lower availability would do equally well. In a few instances in this country the surplus gas is sold to gas undertakings in the neighbourhood of the coke-ovens; and in these cases full advantage is taken of its high availability. In Northumberland and Durham the surplus gas from the coke-ovens is used for the generation of electricity by steam-boilers and engine; the current produced being fed into the main circuit of the Newcastle Power Co. In this case the high availability the gas therms is thrown away in doing work *which could be done equally well by cheaper* therms in the form of coal or coke. The tar and ammonia which are recovered from the coke-ovens take their place side by side with the same products of carbonisation in gasworks. The hard coke, owing to its density, and the practical absence of volatile matter, is quite unsuitable as a domestic fuel, except in specially constructed stoves or waterheaters.

The future development of the coking industry must mainly be determined by its intimate association with the iron and steel industry.

In the gas industry, the fuel problems of the *future have a new interest since the publication of* the report of the Fuel Research Board on the results of their inquiry into the subject of gas standards. As you are no doubt aware, the results of this inquiry led to the adoption by the Board of Trade of a new method of charging the consumer for the gas which passes through his meter. The volume of this gas is still measured and recorded; but the consumer no longer pays on thousands of cubic feet, but on the product of the multiplication of the number of cubic feet passed by the standard calorific value of the gas per cubic foot. The unit of charge is the "therm," *which is the name adopted for 100,000 British* thermal units. Under this system it is now possible to give gas undertakings a wide latitude in the selection of the standard of calorific value which they adopt, and therefore a much wider choice of the methods by which the gas is manufactured. In the report it was stated that the great gain for the gas undertakings under the new system would be that no undue legislative restrictions would limit them in their development of the most economical production of thermal units in the form of gas. It was pointed out that there was still great scope for this development, as, according to present practice, only from 21 to 24 per cent of the total potential thermal units of the coal is being sold in the form of gas.

To increase this percentage, two methods were available, both depending on the production of water gas by one or other of the reactions between *steam and carbon at a high temperature.* The first of these methods was the old-established one in which a portion of the coke produced in the retorts was transferred to a separate producer, in which it was raised to bright incandescence by an air-blast and then subjected to the action of a current of steam. The thermal efficiency of this operation ranged from 45 to 55 per cent, according to the method of blowing-up and steaming adopted. The second method has recently been chosen in connection with vertical retorts. In this case the water-gas reactions are carried out in the lower part of the column of red-hot coke in the *retort itself, by passing through it a current of* steam. The volume of gas produced is much increased, though its calorific value is reduced by the addition of water gas to the hydrocarbon gas resulting from the carbonisation of the coal.

It was foreseen by the Fuel Research Board that the introduction of the new thermal standard would open the way to a more general adoption of this method; and a setting of vertical retorts was installed at the Fuel Research Station with the object of obtaining trustworthy data as to the conditions and the limitations of the steaming process. A full report on the results of the experi*mental working during the past year was recently* presented to the Institution of Gas Engineers.

As the experimental plant at the Fuel Research Station is especially adapted for the obtaining of full and accurate thermal and other data, it is now possible to speak with considerable confidence on the economic bearings of this process as applied to several distinct types of coal. Two of the questions which it was proposed to answer were:

1. Under pre-arranged conditions of temperature and percentage of steam, how will the yields of the principal products—gas, tar, coke, and ammonia—be affected in different types of coal?
2. To secure the increased yields of products, how much extra heat must be supplied to the retorts?

The gain which is of most importance to the gas industry is that of "therms" in the form of saleable gas. It had been common knowledge for some years that this gain by steaming was an assured one, if gas of a calorific value of 400 to 450 *B.Th.U. could be established as a saleable commodity.* It was not equally certain what the effect of steaming would be on the other products—tar, coke, and ammonia.

We can now say with confidence that there is not only a very substantial gain in therms in the form of gas, but also in the yields of tar and ammonia. I will only quote the results of one set of

tests, which were carried out on a South Yorkshire coal of good quality.

At a working temperature of 1260° C., and with 21 per cent of steam, the gains per ton of coal were: 22 therms in the form of gas; 34lb. of tar; and 6lb. of ammonium sulphate. While without steam only 23 per cent of the potential heat of the coal was obtained in the form of gas; with steam, 33 per cent was obtained. The extra heat which had to be supplied to the retorts in order to produce these results was ten therms per ton of coal carbonised. It is estimated that the additional value of the products obtained by steaming amount to at least 10s. per ton of coal carbonised.

The general adoption of steaming in vertical retorts will almost certainly be followed by a great extension of the use of this form of retort, and a very substantial saving will result, both as regards gas undertakings and consumers at large.

Conclusions.—From this brief review, it appears that coal is likely to remain for a long time the world's chief source of fuel. Its more efficient use may be secured:—

1. By more careful sorting and preparation at the mines.
2. By the improvement of boiler firing on well-known lines.
3. By the sorting-out of its combustible constituents into fuels of higher availability or convenience by preliminary carbonisation carried out either at high or low temperatures. This has an important bearing on the development of home sources of fuel oil and motor spirit and on the production of smokeless solid fuel for domestic purposes.

The development of oil shales as a source of liquid fuels is still only in its initial stages; but it has evidently a great future.

The problems of the utilisation of peat, which cover a wide range, both technically and economically, are mainly of local importance, and are not likely to affect the fuel supplies of the world to any great extent.

The production of alcohol on a really large scale as a motor fuel of high availability bristles with economic and technical difficulties; and it is still too soon to pronounce an opinion on the possibilities of the future.

Most, if not all, of these problems on their technical side are probably capable of solution by the skill and application of the industrial pioneers of the world; but the most difficult of the fuel problems of the future are those into which the human element enters so largely. At home, the relations of the wage-earning classes with the actual leaders who initiate and direct our industrial policy, and abroad, our relations with other nations who are equally interested with ourselves in the natural resources of the world, are profoundly affected by the spirit of the times. This spirit, as it is manifesting itself to-day, is fatal to the progress of reconstruction and development on any extensive scale; and we, whose chief interest in life lies in the control and use of the powers and resources of Nature for the service of man, can only continue to do the work next our hand while we cherish the hope that the better side of human nature, which we know is only temporarily overshadowed, will gradually reassert itself.

CORRESPONDENCE.

MINERS' CONFERENCE AND F.B.I.

To the Editor of the Chemical News.

SIR,—At the Miners' Conference at Llandudno on the 19th inst., Mr. Gavan Duffy was reported generally in the Press as having said that the Federation of British Industries had 376 of their members in the House of Commons; this group, in his opinion, possessing complete control over the Government.

Statements of this kind have been made by responsible Labour leaders in every part of the country, though without the slightest foundation. It seems necessary, therefore, to correct an error which such a large number of Labour publicists are making. The facts can be clearly stated as follows:—

The Federation of British Industries takes no part in politics whatever, and has never at any time supported or worked for Parliamentary candidates. It happens in the ordinary course of events that there are betwen 70 and 80 Members of Parliament who are connected with firms which are Members of the Federation, but in no single instance can it be said that the Federation had any part in these being elected.—I am, &c.,

J. D. BENBOW HEBBERT
Director's Department.

CHEMICAL NOTICES FROM FOREIGN SOURCES.

Comptes Rendus Hebdomadaires des Séances de l'Academie des Sciences. Vol. clxxiii., No. 6.

"New Spectrum of Cæsium."—By M. L. Dunoyer.

"New Revision of the Density of Gaseous Oxygen."—By MM. E. Moles and F. Gozalez.

"Synthesis and Dehydration of Ethyl-propyl-phenyl-cartinol."—By M. Vartkès Véramian.

NOTES.

CONGRESS OF APPLIED CHEMISTRY.—The *Société de Chimie Industrielle de France* will hold a meeting of its many French and foreign members on October 9, 10, 11, and 12. This meeting, which will constitute a veritable congress of industrial chemistry, will comprise 34 sections, corresponding to the various applications chemistry: analytical chemistry; factory equipment; laboratory equipment; gas and coke industry; hydrocarbons, petrols; distillation of wood and derivatives; refrigeration industries; waters; metallurgy; electrometallurgy; precious metals; major chemical industries; electrochemistry; lime, cements, and building materials; glass and enamel manufacture and ceramics; minor chemical industries; rare earths and radio-active substances; colouring materials; pharmaceutical and photographic products; powders; explosives; essences and natural and synthetic perfumes; resins; lacs; varnishes, waxes; caoutchouc and substitutes; fats, soaps, candles, glycerines; cellulose paper; plastic materials and artificial textiles; bleaching, dyeing, printing; tinctorial extracts and tannins; tanning and allied in-

dustries; fermentation industries; oonology; cider manufacture; brewing; distilling; sugar manufacture; manufacture of starch and glucose; dairying; foods; agricultural chemistry; soils and the use of manures. Important questions will be discussed by the most renowned specialists. The Congress, which will he held at the Conservatoire des Arts et Metiers, will be opened on the evening of October 9 by a reception of the members. The opening meeting will take place at 9.30 a.m. on the 10th. M. Dior, the Minister of Commerce, presiding. Many celebrities of the scientific and industrial world have promised to give lectures during the congress, and the closing meeting will take place on the 11th, at 5 o'clock, when M. Loncheur, Minister of the Liberated Districts, will take the chair. A general banquet will follow at the Palais d'Orsay, M. Lefebre du Prey, Minister of Agriculture presiding, and the next day the members of the Congress will pay visits to various factories.

EXHIBITION OF CHEMISTRY.—An Exhibition of Chemistry, organised under the patronage of the Minister of Commerce by the *Société de Chimie Industrielle* on the occasion of the First Annual Meeting will be held from October 7 to 16 at the Conservatoire Nationale des Arts et Métiers. This Exhibition, the germ of future chemical exhibitions, will include only two sections: the Equipment of the Laboratory and Industrial Control; and Colouring Materials. Most French firms are included amongst the exhibitors. The novelty and diversity of the goods and products which they propose to send cannot fail to attract many visitors interested in the progress and development of various branches of chemistry.

INSTITUTION OF ELECTRICAL ENGINEERS.—At a meeting of the Privy Council held at Buckingham Palace on Wednesday, August 10, 1921, the petition of the Institution for a Royal Charter of Incorporation was approved, and a Royal Charter has now been granted. His Majesty the King has also been graciously pleased to intimate his willingness to become Patron of the Institution.

TECHNICAL COLLEGE, BRADFORD.—The Calendar of the College for the Session 1921-22 gives details of the full-time (day) and part-time (mainly evening) courses in the departments of textile industries, chemistry, dyeing, mechanical, civil, and electrical engineering, and biology of the College. The full-time courses extend over three or four years, and lead to the Diploma of the College, and the part-time courses, which involve attendance on three evenings a week during three or five sessions, lead to Senior and Advanced Course Certificates of the College. The courses have been specially designed to meet the needs of students wishing to receive a technological training which will enable them to occupy higher positions in industry. The full-time courses in the College are of University standard, and candidates for admission to these courses who have not passed the Matriculation Examination or one of its equivalent examinations, are required to pass the College Entrance Examination, the standard of which is approximately the same as that of the Matriculation Examination. Special consideration is, however, given to the cases of students who have been in whole-time industrial employment for several years, and who may wish to enter one of the full-time courses. The full-time courses have recently been modified with a view to meeting the requirements of those candidates who present themselves for the Diploma of the College and who may wish, at the same time, to present themselves for one of the degree examinations of the University of London. The part-time (evening) courses in the College are intended to meet the needs of those students who are engaged in industry during the greater part of their time. These courses form a large and important part of the work of the College. Many of the advanced courses are attended by those students who have already completed systematic technological courses, and have entered industry, but who wish to keep abreast with the various developments which are continually taking place. In addition to the organised courses, the College also provides special facilities for those students who may wish to undertake advanced study. Students may also undertake research in the various departments of the College, and with a view to the further development of this part of the work of the College, additional equipment and accommodation is being provided. The advanced work of the College includes special post-graduate courses suitable for candidates wishing to prepare themselves for the examination for the Diploma in Public Health of the Royal College of Physicians and Surgeons. The equipment of the College is extensive, and includes a complete plant for the washing, carding, combing, spinning, weaving, dyeing, and finishing of textiles. A special feature of the equipment is the Power House, which has been arranged for demonstration purposes, and which supplies the whole of the power and light required by the College. Mention should also be made of the new engineering apparatus, which will provide special facilities for microphotographic work, for automobile engineering, and for heat treatment. Registration for the part-time courses in the College will take place from September 13 to 17, and for the full-time courses in the College from September 20 to 23. In view of the limited accommodation now available, applications for admission for the full-time courses should be made without delay.

JAPANESE LACQUER INDUSTRY.—The centres of the Japanese industry are Wajimi and Yamashiro in Tshikawa. Before the war business greatly declined because Chinese varnish was often employed, which is not so good, and the wood was not well prepared. Consequently the objects were not sufficiently resisting for dry climates of Europe and America. Moreover, German pasteboard imitations competed keenly with cheap Japanese lacquered articles. Consumption has now increased, but two-thirds of the varnish employed comes from China, where wild trees are tapped. The lacquer obtained is not sufficiently purified, and is inferior to the Japanese product. —*Matières Grasses*, July, 1921.

A PLATINUM SUBSTITUTE.—The employment of crucibles made with an alloy, *platino* (Au+Pt), is recommended by Mr. Van der Marck. These crucibles are not suitable for electrolytic estimates nor analyses made above 1000° C., but they are quite good for estimates of $CaCO_3$, $BaSO_4$, Fe_2O_3, ZnO, &c. The alloy in question is clearly inferior to platinum for sulphuric and nitric acids; it resists the action of KOH and KNO_3 at a red heat.—*Chimie et Industrie*, July, 1921.

FREE BRITISH PROPAGANDA AT THE TRIESTE SAMPLES FAIR.—The authorities of the Annual Trieste Samples Fair, which commences on Sept. 11, have invited H.M. Government to form a British Propaganda and Information Bureau at the Fair. The stand has been placed at the disposal of the British Consul-General free of charge, and the organisation of the Bureau has commenced. Trade catalogues, photographs, and general literature will be displayed on the stand, and information supplied in response to commercial enquires. At the same time, every effort will be made to stimulate the interests of the Italian, Balkan, and Levantine visitors to the Fair in British production generally, and in travel in the United Kingdom. The object of the Fair authorities in making their offer is to enable those British firms who cannot participate individually to make known the range of their products to the buyers at the Fair. There will be no expense to United Kingdom firms whose literature is displayed at the Propaganda Bureau, apart from the cost of forwarding it to Trieste. So far as possible all catalogues, &c., should be in Italian. Firms interested should despatch such matter by express post not later than September 1st to the British Consulate General, Trieste, marked "British Propaganda Bureau." As the space available is somewhat limited, the number of catalogues despatched by any one firm should not exceed 50, and of leaflets 500.

NEW COMPANIES.

The under-mentioned particulars of New Companies recently registered are taken from the Daily Register compiled by Jordan & Sons, Limited, Company Registration Agents, Chancery Lane, W.C.2.

BYPRODUCTS EXTRACTIONS, LIMITED.—(176337)—Registered August 17th, 1921. Donington House, Norfolk Street, Strand, W.C.2. To acquire an Invention in relation to the treatment, application or use for commercial utility or scientific purposes of Sewage and other Waste. Nominal Capital: £10,000 in 10,000 Ordinary Shares of £1 each. Directors: H. L. Davis, 7a, Courtfield Gardens, S.W.5.; W. Hunt, 23, Cecil Mansions, Balham, S.W.17; A. Lyle-Samuel, M.P., Dower House, Sizewell-sum-Leiston, Suffolk; G. Sievwright, 25, Ryder Street, St. James's, S.W.; J. Sievwright, 25, Ryder Street, St. James's, S.W. Qualification of Directors: 1 Share. Remuneration of Directors: £100 each.

ROWAND & CO., LIMITED.—(176354)—Registered August 17th, 1921. 1, Crosshall Street, Liverpool. To carry on the business of Chemists and Druggists, etc. Nominal Capital: £500 in 500 Shares of £1 each. Directors: E. M. Murphy; T. E Hughes. Qualification of Directors: 1 Share. Remuneration of Directors: To be voted by Company.

D. T. EVANS, LIMITED.—(176307)—Registered August 16th, 1921. To acquire and carry on the business of Wholesale and Retail Chemists and Druggists. Nominal Capital: £25,000 in 25,000 Shares of £1 each. Directors: D. T Evans, Farninghan Lodge, Margate (Governing Director); Dorothy C. Evans, Farninghan Lodge, Margate; E. Button. *Qualification of Directors: 100 Shares.* Remuneration of Directors: To be voted by Company.

New Patents.

THIS List is specially compiled for the *Chemical News* by Messrs. Rayner & Co., Registered Patent Agents, of 5, Chancery Lane, London, W.C.2., from whom all information relating to Patents, Trade Marks and Designs can be obtained gratuitously.

Latest Patent Applications.

21170—Eisenwerkges.-Maximiliansbutte.—Process for treatment of phosphorous compounds for manurial purposes. August 9.

21369—Gawalowski, A.—Process for production of synthetic camphor. August 11.

20969—Kulas, C.—Process for production of resinous products of condensation from phenol and formaldehyde. August 10.

21342—Stacey, F.—*Dynamo-electric machines for producing* oxides of nitrogen. August 11.

21321—Walker, D. D.—Fractional distallation of crude naphtha. August 11.

Specifications published this Week.

167219—Wade, H.—Process of catalytic oxidation.

149648—Schmiedel, T. and Klencke, H.—Process for the production of sulphuric acid.

167313—Spence & Sons, Ltd., P., Spence, H. and Craig, T. J. I.—Purification of sulphur.

143550—Nitrogen Corporation.—Production of ammonia.

157850—Haakh.—Manufacture of oxyarylaldehydes.

Abstract Published this Week.

Sodium Formate.—Patent No. 165163.—Mr. M. Enderli, of Oestrich, Rheingau, Germany has Patented an improved process for producing Sodium Formate. Carbon Monoxide is introduced into water containing sodium sulphate and lime, the sodium sulphate being maintained at a concentration not greater than 7 per cent calculated as Na_2SO_4. This concentrated may be regulated by the presence of basic sodium calcium sulphate, $Na_4Ca_3(SO_4)_4(OH)_2$, obtained by heating calcium or sodium hydroxide in water with sodium sulphate and calcium sulphate, or with substances containing or forming these compounds, *e.g.*, calcium sodium sulphate or sodium chloride and calcium sulphate. Another method of maintaining the sodium sulphate concentration consists in adding sodium sulphate or calcium sodium sulphate or basic sodium calcium sulphate to replace the sulphate as it is cousumed, excess of lime being either present in the reaction vessel or gradually added thereto.

Messrs. Rayner & Co., will obtain printed copies of the published specifications and will forward on post free for the official price of 1/- each.

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THE CHEMICAL NEWS.

VOL. CXXIII., No. 3204.

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

EDINBURGH, 1921.

INAUGURAL ADDRESS OF THE PRESIDENT.

SIR T. EDWARD THORPE, C.B., D.Sc., Sc.D., LLD., F.R.S., Hon. F.R.S. Edin.

THE British Association for the Advancement of Science owes its origin, and, in great measure, its specific aims and functions, to the public spirit and zeal for the interests of science of Scotsmen. Its virtual founder was Sir David Brewster; its scope and character were defined by Principal Forbes. In constitution it differed from the migratory scientific associations existing on the Continent, which mainly served to promote the social intercourse of their members by annual gatherings, in that it was to be a permanent organisation, with a settled establishment and headquarters, which should have not merely its yearly reunions, but which, "by methods and by influence peculiarly its own, should ontinue to operate during the intervals of these public assemblies, and should aspire to give an impulse to every part of the scientific system; to mature scientific enterprise; and to direct the labours requisite for discover."

Although, for reasons of policy, it was decided that its first meeting of September 27, 1831, should be held at York, as the most central city for the the three kingdoms, and its second and third meetings at the ancient Universities of Oxford and Cambridge respectively, it was inevitable that the Association should seize the earliest opportunity to visit the Metropolis of Scotland where, as an historical fact, it may he said to have had its origin.

The meeting in this city of September 8, 1834, was noteworthy for many reasons. It afforded the first direct proof that the Association was fulfilling its purpose. This was shown by the popular appreciation which attended its activities, by the range and character of its reports on the state and progress of science, by the interest and value of its sectional proceeding, and by the mode in which its funds were employed. In felicitous terms the president of the preceding year, the Rev. Professor Sedgwick, congratulated the gathering "on the increased strength in which they had assemhled, in a place endeared to the feelings of every lover of science by so many delightful and elevating recollections, especially by the recollection of the great men whom it had fostered, or to whom it had given hirth." In a few brief sentences Professor Sedgwick indicated the great power which this Association is able to apply towards the advancement of science by combination and united action, and he supported his argument by pointing to the results which it had already achieved during the three short years of its existence. Professor Sedgwick's words are no less true to-day. His contention that one of the most important funcions of this philosophical union is to further what he termed the "commerce of ideas" by joint discussions on subjects of kindred interest, has been endorsed by the recent action of the Council in bringing the various sections into still closer touch with each other with a view to the discussion of common problems of general interest. This slight reorganisation of the work of the Sections, which is in entire accord with the spirit and aims of the Association, as defined by its progenitors and formulated in its constitution, will take effect during the present meeting. Strictly speaking, such joint sectional discussions are not unknown in our history, and their utility and influence have been freely recognised. But hitherto the occasions have been more or less informal. They are now, it is hoped, to be part of the regular official procedure of the meetings, to which it is anticipated they will afford additional interest and value.

Another noteworthy change in our procedure is the introduction of discussions on the addresses of the Presidents of Sections. Hitherto these addresses have been formally read and never discussed. To the extent that they have been brief chronicles of the progress of the special departments of science with which the section is concerned they have given but little opportunity for discussion. With the greatly increased facilities which now exist for every worker to keep himself informed of the development of the branch of knowledge in which he is more particularly interested, such *résumés* have in great measure lost their true purpose, and there has, consequently, been a growing tendency of late years for such presidential addresses to deal with contemporary topics of general interest and of fundamental importance, affording ample opportunity for a free exchange of opinion. The experiment will certainly conduce to the interest of the proceedings of the sections, and will contribute to the permanent value of their work. We see in these several changes the development of ideas connected with the working of the Association which may be said to have had their birth at its first meeting in Edinburgh, eighty-seven years ago.

Sixteen years later, that is, on July 21, 1850, Edinburgh again extended her hospitality to the British Association, which then honoured itself by electing the learned Principal of the United Colleges of St. Salvator and St. Leonard, St. Andrews, to the presidential chair—at once a tribute to Sir David Brewster's eminence as a natural philosopher, and a grateful recognition of his services to this body in suggesting and promoting its formation.

On the occasion of his inaugural address, after a brief account of recent progress in science, made with the lucidity of expresson which characterised all the literary efforts of the learned biographer of Newton and versatile editor of the *Edinburgh Encyclopædia*, the *Edinburgh Magazine*, and the *Edinburgh Journal of Science*, the President dwelt upon the beneficient influence of the Association in securing a more general attention to the objects of science, in effecting a removal of disadvantages of a public kind that impeded its progress. It was largely to the action of the Asso-

ciation, assisted by the writings and personal exertions of its members, that the Government was induced to extend a direct national encouragement to science and to aid in its organization.

Brewster had a lofty ideal of the place of science in the intellectual life of a community, and of the just position of the man of science in the social scale. In well-weighed words, the outcome of matured experience and of an intimate knowledge of the working of European institutions created for the advancement of science and the diffusion of knowledge, he pleaded for the establishment of a national institution in Britain, possessing a class of resident members who should devote themselves wholly to science—with a place and station in society the most respectable and independent—"free alike," as Playfair put it, "from the embarrassments of poverty or the temptations of wealth." Such men, "ordained by the State to the undivided functions of science," would, he contended, do more and better work than those who snatch an hour or two from their daily toil or nightly rest.

This ideal of "combining what is insulated, and uniting in one great institution the living talent which is in active but undirected and unbefriended exercise around us," was not attained during Brewster's time; nor, notwithstanding the reiteration of incontrovertible argument during the past seventy years, has it been reached in our own.

I have been led to dwell on Sir David Brewster's association with this question of the relations of the State towards research for several reasons. Although he was not the first to raise it—for Davy more than a century ago made it the theme of presidential addresses, and brought his social influence to bear in the attempt to enlist the practical sympathy of the Government—no one more consistently urged its national importance, or supported his case with a more powerful advocacy, than the Principal of the University of Edinburgh. It is only seemly, therefore, that on this particular occasion, and in this city of his adoption, where he spent so much of his intellectual energy, I should specially allude to it. Moreover, we can never forget what this Association owes to his large and fruitful mind. Every man is a debtor to his profession, from which he gains countenance and profit. That Brewster was an ornament to his is acknowledged by every lover of learning. That he endeavoured to be a help to it was gratefully recognised during his lifetime. After his death it was said of him that the improved position of men of science in our time is chiefly due to his exertions and his example.

I am naturally led to connect the meeting of 1850 with a still more memorable gathering of this Association in this city. In August, 1871—just over half-a-century ago—the British Association again assembled in Edinburgh under the presidency of Lord Kelvin—then Sir William Thomson. It was an historic occasion by reason of the address which inaugaurated its proceedings. Lord Kelvin, with characteristic force and insistence, still further elaborated the theme which had been so signal a feature of Sir David Brewster's address twenty years previously: "Whether we look to the honour of England," he said, "as a [illegible] promoting physical science, or to those vast economical advantages which must accrue from such establishments, we cannot but feel that experimental research ought to be made with us an object of national concern, and not left, as hitherto, exclusively to the private enterprise of self-sacrificing amateurs, and the necessarily inconsecutive action of our present Governmental Departments and of casual committees."

Lord Kelvin, as might have been anticipated, pleaded more especially for the institution of physical observatories and laboratories for experimental research, to be conducted by qualified persons, whose duties should be not teaching, but experimenting. Such institutions as then existed, he pointed out, only afforded a very partial and inadequate solution of a national need. They were, for the most part, "absolutely destitute of means, material, or *personnel*, for advancing science, except at the expense of volunteers, or of securing that volunteers should be found to continue such little work as could then be carried on."

There were, however, even then, signs that the bread cast upon the waters was slowly returning after many days. The establishment of the Cavendish Laboratory at Cambridge, by the munificence of its then Chancellor, was a notable achievement. Whilst in its constitution as part of a university discipline it did not wholly realize the ideal of the two Presidents, under its successive directors, Prof. Clerk-Maxwell, the late Lord Rayleigh, and Sir J. J. Thomson, it has exerted a profound influence upon the development of experimental physics, and has inspired the foundation of many similar educational institutions in this country. Experimental physics has thus received an enormous impetus during the last fifty years, and although in matters of science there is but little folding of the hands to sleep, "the divine discontent" of its followers has little cause for disquietude as regards the position of physics in this country.

In the establishment of the National Physical Laboratory we have an approach to the ideal which my predecessors had so earnestly advocated. Other Presidents, among whom I would specially name the late Sir Douglas Galton, have contributed to this consummation. The result is a remarkable testimony to the value of organised and continuous effort on the part of the British Association in forming public opinion and in influencing Departmental action. It would, however, be ungrateful not to recall the action of the late Lord Salisbury—himself a follower of science and in full sympathy with its objects—in taking the first practical steps towards the creation of this magnificent national institution. I may be allowed, perhaps, to refer to this matter, as I have personal knowledge of the circumstances, being one of the few survivors of the Committee which Lord Salisbury caused to be formed, under the chairmanship of the late Lord Rayleigh, to enquire and report upon the expediency of establishing an institution in Great Britain upon the model of certain State-aided institutions already existing on the Continent, for the determination of physical constants of importance in the arts, for investigations in physical problems bearing upon industry, for the standardisation and verifi- [illegible]

purposes of metrology. I do not profess to give the exact terms of the reference to the Committee, but, in substance, these were recognised to be the general aims of the contemplated institute. The evidence we received from many men of science, from Departmental officers, and from representatives of engineering and other industrial establishments was absolutely unanimous as to the great public utility of the projected laboratory. It need hardly be said that the opportunity called forth all the energy and power of advocacy of Lord Kelvin, and I well remember with what strength of conviction he impressed his views upon the Committee. That the National Physical Laboratory has, under the ability, organising power, and business capacity of its first director, Sir Richard Glazebrook, abundantly justified its creation is recognised on all hands. Its services during the four years of war alone are sufficient proof of its national value. It has grown to he a large and rapidly increasing establishment, occupying itself with an extraordinary range of subjects, with a numerous and well-qualified staff, engaged in determinative and research work on practically every branch of pure and applied physics. The range of its activities has been further increased by the establishment since the war of co-ordinating research boards for physics, chemistry, engineering, and radio-research. Government Departments have learned to appreciate its services. The photometry division, for example, has been busy on experiments on navigation lamps for the Board of Trade, on miners' lamps for the Home Office, and on motorcar headlamps for the Ministry of Transport, and on the lighting of the National Gallery and the Houses of Parliament. Important work has been done on the forms of ships, on the steering and manœvring of ships, on the effect of waves on ship resistance, on the interaction between passing ships, on seaplane floats, and on the hulls of flying-boats.

It is also actively engaged in the study of problems connected with aviation, and has a well ordered department for aerodynamical research.

It can already point to a long and valuable series of published researches, which are acknowledged to be among the most important contributions to pure and applied physics which this country has made during recent years.

I may be pardoned, I hope, for another personal reference, if I recall that it was at the Edinburgh meeting, under Lord Kelvin's presidency, fifty years ago, that I first became a member of this Associtton, and had the honour of serving it as one of the secretaries of its chemical section. Fifty years is a considerable span in the life of an individual, but it is a relatively short period in the history of science. Neverless, those fifty years are richer in scientific achievement and in the importance and magnitude of the utilitarian applications of practically every branch of science than any preceding similar interval. The most cursory comparison of the state of science, as revealed in his comprehensive address, with the present condition of those departments on which he chiefly dwelt, will suffice to show that the development has been such that even Lord Kelvin's penetrative genius, vivid imagination, and sanguine temperament could hardly have anticipated. No previous half-century in the history of science has witnessed such momentous and far-reaching achievements. In pure chemistry it has seen the discovery of argon by Rayleigh, of radium by Madame Curie, of helium as a terrestrial element hy Ramsay, of neon, xenon, and krypton by Ramsay and Travers, the production of helium from radium by Ramsay and Soddy, and the isolation of fluorine by Moissan. These are undoubtedly great discoveries, but their value is enormously enhanced by the theoretical and practical consequences which flow from them.

In applied chemistry it has witnessed the general application of the Gilchrist-Thomas process of iron-purification, the production of calcium cyanamide by the process of Frank and Caro, Sabatier's process of hydrogenation, a wide-spread application of liquefied gases, and Haber's work on ammonia synthesis—all manufacturing processes which have practically revolutionized the industries with which they are concerned.

In pure physics it has seen the rise of the electron theory, by Lorentz; Hertz's discovery of electro-magnetic waves; the investigation of cathode rays by Lenard, and the elucidation of crystal structure by Bragg.

It has seen, moreover, the invention of the telephone, the establishment of incandescent lighting, the electric transmission of force, the invention of the cinematograph, of wireless telegraphy, the aplication of the Röntgen rays, and the photographic reproduction of colour.

In physical chemistry, it has witnessed the creation of stereo-chemistry by Van t'Hoff and Le Bel, Gibbs' work on the phase rule, Van t'Hoff's theory of solutions, Arrhenius's theory of ionic dissociation, and Nernst's theory of the galvanic cell.

Such a list is far from complete, and might he greatly extended. But it will at least serve to indicate the measure of progress which the world owes to the development and application during the last fifty years of the two sciences—physics and chemistry—to which Lord Kelvin specially referred.

The more rapid dissemination of information concerning the results of recent or contemporary investigation, which Lord Kelvin so strongly urged as 'an object to which the powerful action of the British Association would be thoroughly appropriate,' has been happily accomplished. The timely aid of the Association in contributing to the initial expense of preparing and publishing monthly abstracts of foreign chemical literature by the Chemical Society is gratefully remembered by British chemists. The example has been followed by the greater number of our scientific and technical societies, and the results of contemporary inquiry in every important branch of pure and applied science are now quickly brought to the knowledge of all interested workers. In fact, as regards the particular branch of science with which I am more directly concerned, the arrangements for the preparation and dissemintion of abstracts of contemporary foreign chemical literature are proving to be a veritable embarrassment of riches, and there is much need for co-operation among the various distributing societies. This need is especially urgent at the present time owing to the greatly increased cost of paper, printing, binding, and indeed of every item connected with publication, which expense, of course,

ultimately falls upon the various societies and their members. The problem, which has already received some attention from those entrusted with the management of the societies referred to, is not without its difficulties,but these are not insoluble. There is little doubt that a resolute and unanimous effort to find a solution would meet with success.

The present high cost of book production, which in the case of specialised books is about three times what it was in 1914, is exercising a most prejudicial effect upon the spread of scientific knowledge. Books on science are not generally among the 'best sellers.' They appeal to a comparatively limited and not particularly wealthy public, largely composed of the professional classes who have suffered in no small measure from the economic effects of the war. The present high price of this class of literature is to the public detriment. Eventually it is no less to the detriment of the printing and publishing trades. Publishers are well aware of this fact, and attempts are being made by discussions between employers and the executives of the Typographical Association and other societies of compositors to reach an equitable solution, and it is greatly to be hoped that it will be speedily found.

All thinking men are agreed that science is at the basis of national progress. Science can only develop by research. Research is the mother of discovery,and discovery of invention. The industrial position of a nation, its manufactures and commerce, and ultimately its wealth, depend upon invention. Its welfare and stability largely rest upon the equitable distrihution of its wealth. All this seems so obvious, and has been so frequently and so convincingly stated, that it is superfluous to dwell upon it in a scientific gathering to-day.

A late distnguished Admiral, you may remember, insisted on the value of reiteration. On this particular question it was never more needed than now. The crisis through which we have recently passed requires it in the interest of national welfare. Of all post-war problems to engage our serious attention, none is more important in regard to our position and continued existence than the nation's attitude towards science and scientific research, and there is no more opportune time than the present in which to seek to enforce the teaching of one of the most pregnant lessons of our late experience.

It is, unfortunately, only too true that the industrial world as in the past underrated the value of research. One indication that the nation is at length aroused to its importance is to be seen in the establishment of the Department of Scientific and Industrial Research, with its many subordinate associations. The outbreak of the Great War, and much in its subsequent history, revealed, as we all know, many national shortcomings, due to our indifference to and actual neglect of many things which are at the root of our prosperity and security. During the War, and at its close various attempts, more or less unconnected, were made to find a remedy. Of the several committees and boards which were set up, those which still exist have now been co-ordinated, and brought under the control of a central organization—the Department of Scientific and Industrial Research. Research has now become a national and State-aided object. For the first time in our history its pursuit with us has been organized by Government action. As thus organized, it seeks to fulfil the aspirations to which I have referred, whilst meeting many of the objections which have been urged against the endowment of research. It must be recognised that modern ideas of democracy are adverse to the creation of places to which definite work is not assigned and from which definte results do not emanate. This objection, which strikes at the root of the establishment of such an institution as Sir David Brewster contemplated, is, to a large extent, obviated by the scheme of the Department of Scientific and Industrial Research. It does not prescribe or fetter research, but, whilst aiding by personal payments the individual worker, leaves him free to pursue his enquiry as he thinks best. Grants are made, on the recommendation of an Advisory Council of experts, to research workers in educational institutions and elsewhere in order to promote research of high character on fundamental problems of pure science or in suitable cases on problems of applied science. Of the boards and committees and similar organizations established prior to or during the War, or subsequent to it, with one or two exceptions, all are now directly under the Department. They deal with a wide range of subjects, such as the Building Research Board, established early in 1920 to organize and supervise investigations on building materials and construction, to study structural failures, and to fix standards for structural materials. The Food Investigation Board deals with the preservation by cold of food, and with the engineering problems of cold storage, with the chemistry of putrefaction, and the agents which induce it, with the bionomics of moulds, and the chemistry of edible oils and fats. The Fuel Research Board is concerned with the immediate importance of fuel economy and with investigations of the questions of oil-fuel for the Navy and Mercantle Marine, the survey of the national coal resources, domestic heating, air polution, pulverised fuel, utilization of peat, the search for possible substitutes for natural fuel oil, and for practicable sources of power alcohol.

The Geological Survey Board has taken over the Geological Survey of Great Britain and the control of the Museum of Practical Geology. The Maintenance of the National Physical Laboratory, originally controlled by a General Board and an Executive Committee appointed by the President and Council of the Royal Society, is now transferred to the Department of Scientific and Industrial Research. A Mines Research Committee and a Mine Rescue Apparatus Committee are attached to the Department. The former is concerned witb such questions as the determination of the geothermic gradient, tbe influence of temperature of intake and return air on strata, the effect of seasonal changes on strata temperature of intakes, the cooling effect due to the evolution of fire-damp, heat production from the oxidation of timber, etc. The Department is also directing enquiries on the preservation and restoration of antique objects deposited in the British Museum. It is concerned with the gauging of rivers and tidal currents, with special reference to a hydrographical survey of Great Britain in relation to the national resources of

water-power. In accordance with the Government policy, four co-ordinating boards have been established to organize scientific work in connection with the fighting forces, so as to avoid unnecessary overlapping and to provide a single direction and financial control. The four boards deal, respectively, with chemical and physical problems, problems of radio-research, and engineering. These boards have attached to them various committees dealing with special enquiries, some of which will be carried out at the National Physical Laboratory. The Government have also authorized the establishment of a Forest Products Research Board.

The Department is further empowered to assist learned or scientific societies and institutions in carrying out investigations. Some of these were initiated prior to the War, and were likely to be abandoned owing to lack of funds. Whenever the investigation has a direct bearing upon a particular industry that had not hitherto been able to establish a Research Association, it had been a condition of a grant that the institution directing the research should obtain contributions towards the cost on a £ for £ basis, either directly through its corporate funds or by special subscriptions from interested firms. On the formation of the appropriate association the research is, under suitable safeguards, transferred to it for continuance. The formation of a number of Research Associations has been stimulated, dealing, for example, with scientific instruments, non-ferrous metals, glass, silk, refractories, electrical and allied industries, pottery, etc.

Grants are made to Research Associations formed voluntarily by manufacturers for the purposes of research, from a fund of a million sterling, placed at the disposal of the Research Department for this purpose. Such Associations, to be eligible for the grant, must submit Articles of Association for the approval of the Department and the Board of Trade. If these are approved, licences are issued by the Board of Trade recognizing the Associations as limited liability companies working without profits. Subscriptions paid to an Association by contributing firms are recognized by the Board of Inland Revenue as business costs of the firms, and are not subject to income or excess profits taxes. The income of the Association is similarly free of income tax. Grants are ordinarily made to these Associations on the basis of £1 for every £1 raised by the Association between limits depending upon the particular industry concerned. In the case of two Research Associations grants are made at a higher rate than £ for £, as these industries are regarded as having a special claim to State assistance on account of their 'pivotal' character. The results of research are the sole property of the Association makng them, subject to certain rights of veto possessed by the Department for the purposes of ensuring that they are not communicated to foreign countries, except with the consent of the Department, and that they may be made available to other interested industries and to the Government itself on suitable terms.

These arrangements have been found to be generally satisfactory, and at the present time twenty-four of such Research Associations have been formed to whom licences have been issued by the Board of Trade. Others are in process of formation, and may be expected to be at work at an early date. These Research Associations are concerned with nearly all our leading industries. The official addresses of most of them are in London; others have their headquarters in Manchester, Leeds, Sheffield, Northampton, Coventry, Glasgow, and Belfast.

The Department has further established a Records Bureau, which is responsible for receiving, abstracting, filing and collating communications from research workers, boards, institutions, or associations related to or supervised by the Department. This information is regarded as confidential, and will not be communicated except in writing, and after consultation with the research worker or organization from which it has been received. Also such non-confidential information as comes into the possession of the Department which is of evident or probable value to those working in touch with the Department is collected and filed in the Bureau and made generally available.

It is also a function of the Bureau to effect economy in preventing repetition and overlapping of investigations and in ensuring that the fullest possible use is made of the results of research. Thus, the programmes of Research Associations are compared in order to ensure that researches are not unwittingly duplicated by different Research Associations. Sometimes two or more Research Associations may be interested in one problem from different points of view, and when this occurs it may be possible for the Bureau to arrange a concerted attack upon the common problem, each Research Association undertaking that phase of the work in which it is specially interested and sharing in the general results.

As researches carried out under the Department frequently produce results for which it is possible to take out patents, careful consideration has been given to the problems of policy arising on this subject, and other Government Departments also interested have been freely consulted. As the result, an Inter-Departmental Committee has been established with the following terms of reference:

(1) To consider the methods of dealing with inventions made by workers aided or maintained from public funds, whether such workers be engaged (*a*) as research workers, or (*b*) in some other technical capacity, so as to give a fair reward to the inventor and thus encourage further effort, to secure the utilization in industry of suitable inventions and to protect the national interest, and

(2) To outline a course of procedure in respect of inventions arising out of State-aided or supported work which shall further these aims and be suitable for adoption by all Government Departments concerned.

About forty patents have been taken out by the Department jointly with the inventors and other interested bodies, but of these, nine have subsequently been abandoned. At least five patents have been developed to such a stage as to be ready for immediate industrial application.

It will be obvious from this short summary of the activities of the Department, based upon information kindly supplied to me by Sir Francis Ogilvie, that this great scheme of State-aided research has been conceived and is administered

on broad and liberal lines. A considerable number of valuable reports from its various boards and committees have already been published, and others are in the press, but it is, of course, much too soon to appreciate the full effects of their operations. But it can hardly be doubted that they are buund to exercise a profound influence upon industries which ultimately depend upon discovery and invention. The establishment of the Department marks an epoch in our history. No such comprehensive organization for the application of science to national needs has ever been created by any other State. We may say we owe it directly to the Great War. Even from the evil of that great catastrope there is some soul of goodness would we observingly distil it out.

I turn now to a question of scientific interest which is attracting general attention at the present time. It is directly connected with Lord Kelvin's address fifty years ago.

The molecular theory of matter—a theory which in its crudest form has descended to us from the earliest times and which has been elaborated by various speculative thinkers through the intervening ages, hardly rested upon an experimental basis until within the memory of men still living. When Lord Kelvin spoke in 1871, the best-established development of the molecular hypothesis was exhibited in the kinetic theory of gases as worked out by Joule, Clausius, and Clerk-Maxwell. As he then said, no such comprehensive molecular theory had ever been imagined before the nineteenth century. But, with the eye of faith, he clearly perceived that, definite and complete in its area as it was, it was 'but a well-drawn part of a great chart, in which all physical science will be represented with every property of matter shown *in dynamical relation to the whole. The prospect* we now have of an early completion of this chart is based on the assumption of atoms. But there can be no permanent satisfaction to the mind in explaining heat, light, elasticity, diffusion, electricity, and magnetism, in gases, liquids and solids, *and describing precisely the relations of* these different states of matter to one another by statistics of great numbers of atoms when the properties of the atom itself are simply assumed. When the theory, of which we have the first instalment in Clausius and Maxwell's work, is complete, *we are but brought face to face with a* superlatively grand question: What is the inner mechanism of the atom?'

If the properties and affections of matter are dependent upon the inner mechanism of the atom, an atomic theory, to be valid, must comprehend and explain them all. There cannot be one kind of atom for the physicist and another for the chemist. The nature of chemical affinity and of valency, the modes of their action, the difference in characteristics of the chemical elements, even their number, internal constitution, periodic position, and possible isotopic rearrangements must be accounted for and explained by it. Fifty years ago, chemists, for the most part, rested in the comfortable belief of the existence of atoms in the restricted sense in which Dalton, as a legacy from Newton, had imagined them. Lord Kelvin, unlike the chemists, had never been in the habit of 'evading questions as to the hardness or indivisibility of atoms by virtually assuming them to be infinitely small and infinitely numerous,' Boscovich, the atom 'as a mystic point endowed with inertia and the attribute of attracting or repelling other such centres.' Science advances not so much by fundamental alterations in its beliefs as by additions to them. Dalton would equally have regarded he atom 'as a piece of matter of measureable dimensions, with shape, motion, and laws of action, intelligible subjects of scientific investigation.'

In spite of the fact that the atomic theory, as formulated by Dalton, has been generally accepted for nearly a century, it is only within the last few years that physicists have arrived at a concepion of the structure of the atom sufficiently precise to be of service to chemists in connection with the relation between the properties of elements of different kinds, and in throwing light on the mechanism of chemical combination.

This further investigation of the 'superlatively grand question—the inner mechanism of the atom' —has profundly modified the basic conceptions of chemistry. It has led to a great extension of our views concerning the real nature of the chemical elements. The discovery of the electron, the production of helium in the radioactive disintegration of atoms, the recognition of the existence of isotopes, the possibility that all elementary atoms are composed either of helium atoms or of atoms of hydrogen and helium, and that these atoms, in their turn, are built up of two constituents, one of which is the electron, a particle of negative electricity whose mass is only 1/1800 of that of an atom of hydrogen, and the other a particle of positive electricity whose mass is practically identical with that of the same atom—the outcome in short, of the collective work of Soddy, Rutherford, J. J. Thomson, Collie, Moseley and others—are pregnant facts which have completely altered the fundamental aspects of the science. Chemical philosophy has, in fact, now definitely entered on a new phrase.

Looking back over the past, some indications of the coming change might have been perceived wholly unconnected, of course, with the recent experimental work which has served to ratify it. In a short paper entitled "Speculative Ideas respecting the Constitution of Matter," originally published in 1863,, Graham conceived that the various *kinds* of matter, now recognised as different elementary substances, may possess one and the same ultimate or atomic molecule existing in different conditions of the movement. This idea, in its essence, may be said to be as old as the time of Leucippus. To Graham as to Leucippus "the action of the atom as one substance taking various forms by combinations unlimited, was enough to account for all the phenomena of the world. By separtion and union with constant motion all things could be done." But Graham developed the conception by independent thought, and *in the light of experimentally* ascertained knowledge which the world owes to his labours. He might have been cognisant of the speculations of the Greeks, but that is no evidence that he was knowingly influenced by them. In his paper Graham uses the terms atom and molecule if not *exactly in the same sense that modern* teaching demands, yet very different from that hitherto required by the limitations of contemporary chemical doctrine. He conceives of a lower order of

founds on his conception an explantion of chemical combination based upon a fixed combining measure, which he terms *metron* its relative weight being one of hydrogen, sixteen for oxygen, and so on with the so-called "elements." Graham, in fact, like Davy before him, never committed himself to a belief in the indivisibility of the Daltonian atom. The origin-original atom may, he thought, be far down.

The idea of a primordial ylé, or of the essential unity of matter, has persisted throughout the ages, and, in spite of much experimental work some of it of the highest order, which was thought to have demolished it, it has survived, revivified and supported by analogies and arguments drawn from every field of natural inquiry. This idea of course was at the basis of the hypothesis of Prout, but which, even as modified by Dumas, was held to be refuted by the momumental work of Stas. But, as pointed out by Marignac and Dumas, anyone who will impartially look at these facts can hardly escape the feeling that there must be some reason for the frequnt recurrence of atomic weights differing by so little from the numbers required by the law which the work of Stas was supposed to disprove. The more exact study within recent years of the methods of determining atomic weights, the great improvement in experimental appliances and technique, combined with a more rigorous standard of accuracy demanded by a general recognition of the far-reaching importance of an exact knowledge of these physical constants, has resulted in intensifying the belief that some natural law must at the basis of the fact that so many of the most carefully determined atomic weights on the oxygen standard are whole numbers. Nevertheless there were well authenticated exceptions which seemed to invalidate its universality. The proved fact that a so-called element may be a mixture of isotopes—substances of the same chemical attributes but of varying atomic weight—has thrown new light on the question. It is now recognised that the fractional values independently established in the case of any one element by the most accurate experimental work of the various investigators are, in effect, "statistical quantities" dependent upon a mixture of isotopes. This result, indeed, is a necessary corollary of modern conceptions of the inner mechanism of the atom. The theory that all elementary atoms are composed of helium atoms, or of helium and hydrogen atoms, may be regarded as an extension of Prout's hypothesis, with, however, this important distinction, that whereas Prout's hypothesis was at best a surmise, with little, and that little only weak, experimental evidence to support it, the new theory is directly deduced from well-established facts. The hydrogen isotope H_3, first detected by J. J. Thomson, of which the existence has been comfirmed by Aston, would seem to be an integral part of atomic structure. Rutherford, by the disruption of oxygen and nitrogen has also isolated a substance of mass 3 which enters into the structure of atomic nuclei, but the which he regards as an isotope of helium, which itself is built up of four hydrogen nuclei together with two cementing electrons. The atomic nuclei of elements of even atomic number would appear to be composed of helium nuclei only, or of helium nuclei with cementing electrons; are made up of helium and hydrogen nuclei together with cementing electrons. In the case of the lighter elements of the latter class the number of hydrogen nuclei associated with the helium nuclei is invariably three, except in that of nitrogen where it is two. The frequent occurrence of this group of three hydrogen nuclei indicates that it is structurally an istope of hydrogen with an atomic weight of three and a nuclear charge of one. It is surmised that it is identical with the hypothetical 'nebulium' from which our 'elements' are held by astro-physicists to be originally produced in the stars through hydrogen and helium.

These results are of extraordinary interest as bearing on the question of the essential unity of matter and the mode of genesis of the elements. Members of the British Association may recall the suggestive address on this subject of the late Sir William Crookes, delivered to the Chemical Section at the Birmingham meeting of 1886, in which he questioned whether there is absolute uniformity in the mass of the atoms of a chemical element, as postulated by Dalton. He thought, with Marignac and Schutzenberger, who had previously raised the same doubt, that it was not improbable that what we term an atomic weight merely represents a mean value around which the actual weights of the atoms vary within narrow limits, or, in other words, that the mean mass is "a statistical constant of great stability". No valid experimental evidence in support of this surmise was or could be offered at the time it was uttered. Maxwell pointed out that the phenomena of gaseous diffusion, as then ascertained, would seem to negative the supposition. If hydrogen, for example, were composed of atoms of varying mass, it should be possible to separate the lighter from the heavier atoms by diffusion through a porous septum. 'As no chemist' said Maxwell, 'has yet obtained specimens of hydrogen differing in this way from other specimens, we conclude that all the molecules of hydrogen are of sensibly the same mass, and not merely that their mean mass is a statistical constant of great stability.' (Clerk-Maxwell, Art. 'Atom' *Ency. Brit.* 9th Ed.) But against this it may be doubted whether any chemist had ever made experiments sufficiently precise to solve this point.

The work of Sir Norman Lockyer on the spectroscopic evidence for the dissociation of 'elementary' matter at transcendental temperatures, and the possible synthetic intro-stellar production of elements, through the helium of which he originally detected the existence, will also find its due place in the history of this new philosophy.

Sir J. J. Thomson was the first to afford direct evidence that the atoms of an element, if not exactly of the same mass, were at least approximately so, by his method of analysis of positive rays. By an extension of this method Mr. F. W. Aston has succeeded in showing that a number of elements are in reality mixtures of isotopes. It has been proved, for example, that neon, which has a mean atomic weight of about 20.2, consists of two isotopes having the atomic weights respectively of 20 and 22, mixed in the proportion of 90 per cent of the former with 10 per cent of the latter. By fractional diffusion through a porous septum an apparent difference of density of 0.7 per cent between the lightest and heaviest fractions was obtained. The kind of experiment

which Maxwell imagined proved the invariability of the hydrogen atom has sufficed to show the converse in the case of neon.

The element chlorine has had its atomic weight repeatedly determined, and, for special reasons, with the highest attainable accuracy. On the oxygen standard it is 35.46, and this value is accurate to the second decimal place. All attempts to prove that it is a whole number—35 or 36—have failed. When, however, the gas is analysed by the same method as that used in the case of neon it is found to consist of at least two istopes of relative mass 35 and 37. There is no evidence whatever of an individual substance having the atomic weight 35.46. Hence chlorine is to be regarded as a complex element consisting of two principal isotopes of atomic weights 35 and 37 present in such proportion as to afford the mean mass 35.46. The atomic weight of chlorine has been so frequently determined by various observers and by various methods with practically identical results that it seems difficult to believe that it consists of isotopes present in definite and invariable proportion. Mr Aston meets this objection by pointing out that all the accurate determinations have been made with chlorine derived originally from the same source, the sea, which has been perfectly mixed for æons. If samples of the element could be obtained from some other source it is possible that other values of atomic weight would be obtained, exactly as in the case of lead in which the existence of istopes in the metal found in various radioactive minerals was first conclusively established.

Argon, which has an atomic weight of 39.88, was found to consist mainly of an isotope having an atomic weight of 40, associated to the extent of about 3 per cent., with an isotope of atomic weight 36. Krypton and xenon are far more complex. The former would appear to consist of six isotopes, 78, 80, 82, 83, 84, 86; the latter of five isotopes, 129, 131, 132, 134, 136.

Flourine is a simple element of atomic weight 19. Bromine consists of equal quantities of two istopes, 79 and 81. Iodine, on the contrary, would appear to be a simple element of atomic weight 127. The case of tellurium is of special interest in view of its periodic relation to iodine, but the results of its examination up to the present are indefinite.

Boron and silicon are complex elements, each consisting of two isotopes, 10 and 11, and 28 and 29, respectively.

Sulphur, phorphorous, and arsenic are apparently simple elements. Their accepted atomic weights are practically integers.

All this work is so recent that there has been little opportunity, as yet, of extending it to any considerable number of the metallic elements. These, as will be obvious from the nature of the methods employed, present special difficulties. It is, however, highly probable that mercury is a mixed element consisting of many isotopes. These have been partially separated by Brönsted and Hervesy by fractional distillation at very low pressures, and have been shown to vary very slightly in density. Lithium is found to consist of two isotopes, 6 and 7. Sodium is simple, potassium and rubidium are complex, each of the two latter elements consisting, apparently, of two isotopes. The accepted atomic weight of cæsium, 132.81, would indicate complexity, but the mass spectrum shows only one line at 133. Should this be confirmed cæsium would afford an excellent test case. The accepted value for the atomic weight is sufficiently far removed from a whole number to render further investigation desirable.

This imperfect summary of Mr. Aston's work is mainly based upon the account he recently gave to the Chemical Society. At the close of his lecture he pointed out the significance of the results in relation to the Periodic Law. It is clear that the order of the chemical or 'mean' atomic weights in the Periodic table has no practical significance; anomalous cases such as argon and potassium are simply due to the relative proportions of their heavier and lighter isotopes. This does not necessarily invalidate or even weaken the Periodic Law which still remains the expression of a great natural truth. That the expression as Mendeléeff left it is imperfect has long been recognised. The new light we have now gained has gone far to clear up much that was anomalous, especially Moseley's discovery that the real sequence is the atomic number, not the atomic weight. This is one more illustration of the fact that science advances by additions to its beliefs rather than by fundamental or revolutionary changes in them.

The bearing of the electronic theory of matter, too, on Prout's discarded hypothesis that the atoms of all elements were themselves built up of a primordial atom—his *protyle* which he regarded as probably identical with hydrogen—is too obvious to need pointing out. In a sense Prout's hypothesis may be said to be now re-established, but with this essential modification—the primordial atoms he imagined are complex and are of two kinds—atoms of the positive and negative electricty—respectively known as protons and electrons. These, in Mr. Aston's words, are the standard bricks that Nature employs in her operations of element building.

The true value of any theory consists in its comprehensiveness and sufficiency. As applied to chemistry, this theory of 'the inner mechanism of the atom' must explain all its phenomena. We owe to Sir J. J. Thomson its extension to the explantion of the Periodic Law, the atomic number of an element, and of that varying power of chemical combination in an element we term valency. This explanation I give substantially in his own words. The number of electrons in an atom of the different elements has now been determined, and has been found to be equal to the atomic number of the element, that is to the position which the element occupies in the series when the elements are arranged in the order of their atomic weights. We know now the nature and quantity of the materials of which the atoms are made up. The properties of the atom will depend not only upon these factors but also upon the way in which the electrons are arranged in the atom. This arrangement will depend on the forces between the electrons themselves and also on those between the electrons and the positive charges or protons. One arrangement which naturally suggested itself is that the positive charges should be at the centre with the negative electrons around it on the surface of a sphere. Mathematical investigations shows that this is a

possible arrangement if the electrons on the sphere are not too crowded. The mutual repulsion of the electrons resents overcrowding, and Sir J. J. Thomson has shown that when there are more than a certain number of electrons on the sphere, the attraction of a positive charge, limited as in the case of the atom in magnitude to the sum of the charges on the electrons, is not able to keep the electrons in stable equilibrium on the sphere, the layer of electrons explodes and a new arrangement is formed. The number of electrons which can be accommodated on the outer layer will depend upon the law of force between the positive charge and the electrons. Sir J. J. Thomson has shown that this number will be eight with a law of force of a simple type.

To show the bearing of this result as affording an explantion of the Periodic Law, let us, to begin with, take the case of the atom of lithium, which is supposed to have one electron *in the outer* layer. As each element has one more free electron in its atom than its predecessor, glucinum, the element next in succession to lithium, will have two electrons in the outer layer *of its atom*, boron will have three, carbon four, nitrogen five, oxygen six, fluorine seven and neon eight. As there cannot be more than eight electrons in the outer layer, *the additional electron in the atom of* the next element, sodium, cannot find room in the same layer as the other electrons, but will go outside, and thus the atom of sodium, like that of *lithium, will have one electron in its outer layer.* The additional electron, in the atom of the next element, magnesium, will join this, and the atom of magnesium, like that of glucinum, will have *two electrons in the outer layer.* Again, aluminium, like boron, will have three; silicon, like carbon, four; phosphorous, like nitrogen, five; sulphur, like oxygen, six; chlorine, like flourine, *seven; and argon, like neon, eight.* The sequence will then begin again. Thus the number of electrons, one, two, three, up to eight in the outer layer of the atom, will recur periodically as we proceed from one element to another in the order of their atomic weights, so that any property of an element which depends on the number of electrons in the outer layer of its atoms will also recur periodically, which is precisely that remarkable property of the elements which is expressed by the Periodic Law of Mendeléeff, or the Law of Octaves of Newlands.

(To be continued).

FURTHER NOTES ON ALUMINIUM.

By E. RATTENBURY HODGES.

To my last notes on aluminium acetate (CHEMICAL NEWS, Oct. 8, 1920, p. 178), I would add the three following.

1. Strong acetic acid combines with Al in presence of hydrogen peroxide. At 58° to 60° F., this reaction is completed in four or five days. However, when Al foil is exposed to acid of like strength, in a flask provided with an inverted receiver and heated to boiling point for a few minutes, no chemical change is apparent. After leaving the whole undisturbed for 18 days, the foil was found intact. Removing the receiver, the contents of the flask were left exposed to the air for a week, then, on testing, a small amount of Al acetate was found. To the original acid and foil in the flask, a few drops of hydrogen peroxide were added. In about 30 hours, all the foil had entered into combination. It therefore seems fairly obvious that air or oxygen is essential to the reaction, *i.e.*, oxidation of the base must precede the production of the salt.

2. In Thorpe's Dictionary it is stated that aluminium is vigorously attacked by bromine. I note, however, that with Al foil slightly warmed, this reaction occurs with brilliant incandescence, and evolution of a heavy grey vapour, which is evidently an anhydrous bromide, the solid residue being a dark brown granular deposit of anhydrous aluminium bromide. The latter soon deliquesces to a clear liquid, which after slow evaporation (in air) yielded a crop of fine colourless tabular crystals. Obviously, due precautions had to be taken during the first stages of this observation. Br-water slowly acted upon this foil, yielding, after a few hours, the normal Al bromide. A strong solution of tartaric acid leaves Al unaffected. The same is true of citric acid, but a cold saturated solution of oxalic acid reacted in the course of some weeks, and completely dissolved the foil. On carefully evaporating the resulting oxalate solution, it was found that a portion of the compound formed an oily-looking film, which, on further drying, assumed the colloid state. As the air was slightly humid, the film, after a few minutes exposure, proved to be hygroscopic. A hot solution of oxalic acid steadily acts, but slackens at 57° C., below 30° C. chemical action proceeds feebly.

3. I note a further property of Al; whereas the metal (in foil) is readily attacked by strong phosphoric acid, yielding the resultant phosphate, the concentrated acid fails to act upon tin, even after several weeks' exposure. Hence this reaction with aluminium serves *inter alia* to distinguish it from tin. The action, under certain conditions, of iodine on Al, is noteworthy, but this item must be reserved for a later communication.

REGULATIONS FOR THE COMPETITIVE SELECTION OF CHEMISTS.

CLASS II.—IN THE GOVERNMENT LABORATORY.

Age.—Candidates must have attained the age of 23 and must not exceed the age of 30 on a date to be fixed in respect of the competition in which they are to take part. A candidate born on the governing date would be admitted on the day he attained the age of 23, but not on the day on which he attained 30.

Nationality.—A candidate must be a natural-born British subject, and born of a father also a natural-born British subject; provided that exception may made in the case of candidates serving in a civil situation to which they were admitted with the certificate of the Civil Service Commissioners, and provided that exception may be made as to the father in the case of candidates who have served in His Majesty's Armed Forces between 4th August, 1914, and 11th November, 1918.

Military Service.—Until further order preference will be given to candidates who have served in His Majesty's Forces between 4th August, 1914, and 11th November, 1918.

Publicity.—The Government Chemist will take such steps as he thinks appropriate to make known the existence of any vacancy or vacancies which he desires to fill on any one occasion, and the Civil Service Commissioners will satisfy themselves that the steps taken have been such as to secure all desirable publicity

Application.—Application shall be made to the Government Chemist, who, after scrutiny of the candidates' credentials, will submit the names of such candidates as appear to have the requiste qualifications for any of the existing or prospective vacancies to the Civil Servce Commissoners, who, if dissatisfied with the number or quality of candidates for any vacancy, may require further search to be made for qualified candidates. Candidates must possess a degree or diploma of a standard not lower than a second class honours degree at a university, and must have had two years' post-graduate experience in chemical work. They should have a working knowledge of technical French and German.

Health and Character.—Candidates must satisfy the Civil Service Commissioners as to their health and character. Until further order, and other things being equal, preference will be given by the Selection Board to candidates who are debarred from active employment by a physical impairment due to the war, and not of a nature to interfere with the discharge of the duties of the post.

Competition. Candidates who pass the scrutiny under Regulation 5 will be admitted to (*a*) an interview before a Selection Board, and (*b*) a written examination in English (the examination in English will include essay writing and précis writing). The Selection Board shall be nominated by the Commissioners in consultation with the authorities of the Department who shall be represented upon it, and, if practicable, one of the Commissioners shall be the Chairman. The Selection Board will take into consideration the candidate's record of experience and education, any recommendations that they may receive from persons named by the candidate as having direct knowledge of his work in the past, the candidate's scientific knowledge, and his personal qualities as shown at the interview; and on their estimation of all the above evidence they will frame their decisions, which will be final. The Selection Board will arrange the candidates in order of merit and the vacancies will be filled by the appointment of the candidates in order from the list, subject to their passing the examination and satisfying the Commissioners that they are eligible in all respects.

Warning.—Any attempt on the part of a candidate to enlist support for his application through Members of Parliament or other influential persons will disqualify him for appointment. The Selection Board will disregard spontaneous recommendations from persons who are not personally acquainted with the candidate's work, whether at school, at the university, in the forces, or otherwise.

Fee.—A fee of £5 will be required from each candidate attending the competition.

Salary.—The scale of salaries is at present under consideration by a Committee, and, pending their report, the commencing salary will be £225, with current Civil Service Bonus.

Competitions under these regulations do not take place at fixed intervals, but are held from time to time on the occurrence of vacancies. No date has at present been fixed for any competition under these regulations, which are liable to alteration from time to time.

NOTES.

At the invitation of the General Manager of the Great Eastern Railway we have been able to make a practical test of their new route to Belgium and the Continent, via Harwich and Zeebrugge. For any hard-worked professional man with but little time to spare the route offers many inducements. The Railway Company has made arrangements by which it is possible to visit Zeebrugge, Bruges, Ghent, Brussels, Antwerp, and the battle area, easily and at a very small expense. It is now possible to leave Liverpool Street Station in the evening and be bowled down to Harwich in a fast train, where a splendid boat waits to take you across to Zeebrugge. from whence a good service of trains makes it easy to travel to any part of Belgium. For ourselves we started at 8 p.m. on Monday, visited Zeebrugge, Bruges, Ghent, Ypres Roulers, Courtrai, Ostend, Blankenburghe, and thoroughly explored the historic Mole of Zeebrugge, recrossing comfortably on Thursday night, and were back at the Office before 9 a.m. on Friday. Railway travelling is cheap in Belgium, and with the exchange at 49 the charges seem ridiculously small; the officials are most obliging and the language presents no difficulty, as nearly everyone knows a little English. The Great Eastern Railway Company also run a special "Sunday in Belgium" trip, the train leaving London on Saturday night, giving a full day in Belgium and enabling one to be home by 8 a.m. on Monday. By this trip it is possible to go inland or to visit Ostend and any of the seaside towns easily as there is good electric train service right along the coast. For this trip no passport is necessary and the return fare is only £2 10s. second class and £3 15s. first. We can recommend the Harwich-Zeebrugge service as affording an easy and economical relief from the worry and pressure of London, and it at least enables one to contrast the unrest and unemployment agitation at home with the quiet industry and labour that is going on in that sorely abused little country across the water.

The Sir John Cass Technical Institute. The new session of the Sir John Cass Technical Institute, Aldgate, E.C.3, will commence on Monday, September 26th. Students will be enrolled during the previous week commencing Monday, September 19th, between 7 and 9 p.m. The courses of instruction at the Institute are especially directed to the technical training of those engaged in chemical, metallurgical, and electrical industries and in the trades associated therewith. Full facilities are provided in the well-equipped laboratories of the Institute for special investigations and research. The instruction in experimental science also provides systematic courses for the examinations of London University and of the Institutes of Physics and Chemistry. Special courses of higher technologi-

cal instruction form a distinctive feature of the work of the Institute. For the forthcoming session these include courses on the Fermentation Industries, Glass Technology, Colloids, Metallography and Pyrometry, Heat Treatment and Mechanical Testing of Metals and Alloys. An important development for the new session is the establishment of courses of instruction in Petroleum Technology. These have been arranged in consultation with representatives of the chief oil companies and have been designed to meet the requirements ofthose engaged in or associated with the practical and scientific control of the petroleum industry. In view of the fact that most of the chief oil companies have their offices and several have their laboratories in the immediate district, the Institute is very favourably situated for this branch of instruction, which it is anticipated will form a most valuable extension of the work of the Institute. The leading oil companies have very generously contributed towards the establishment of this department of petroleum technology.

IS AMERICA LEADING BRITISH INDUSTRIES?—*In* the current issue of the *Industrial League and Council Journal*, Mr. E. J. P. Benn, who has recently returned from America, gave his impressions of labour and industry in that country. On the question of social legislation, he said:—"Imagine a humble student of social problems, searching through a distant land, endeavouring to find someone with whom he could discuss intelligently such elementary matters as Old Age Pensions, Health Insurance, Unemployment Pay, or even Poor Law itself. Imagine a land with 110 million civilized persons without a political Labour Party, and with, so far as I am able to judge, nu earthly chance of ever getting one. Imagine a land in which even the workers never heard the word 'ca-canny', and regard restriction of output as a mythical madness that does not really exist." On the status of the workers, he remarked:—"It is frequently said that America is fifty years behind us in matters of social reform, and particularly in Labour organization. I had the advantage of three long talks with that veteran leader, Sam Gompers, and I put that point to him. Mr. Gompers was indignant, and claimed that so far from being fifty years behind us, the United States of America are 100 years ahead of us. He claims that the true test of success of a Labour movement is not to be found in the violence of its political programme; there is a more serious, a more effective test. Go to the homes of the people; look at the social and economic status of the wokers. He points with pride to the six million working-class homes which are either completely or partly owned by their workman occupants. He called my attention to the 12 million automobiles among the 110 million people; sufficient at a pinch to move the whole population at one go. It is stated that there are no less than 15 million owners of shares, stock or some form of property among the citizens of the United States. America, like the rest of the world, is having her revolution, but it is a very different revolution from any of the many brands that we are familiar with in Europe. The revolution in America is taking the form of the transference of large blocks of industrial capital into the hands of the workers in industry." As a general comparison of America and Britain as regards Industry and Commerce, he said: "In a word, the whole force of public opinion in America is directed to teaching its people how to *push*. Our opinion on the contrary seems to be with teaching its people how to *lean*." A general review of the activities of the Whitley Council, and reviews of industrial books makes up a very interesting magazine.

RAINFALL.—The mean rainfall during May at 12 stations which have been selected as giving equal representation for all parts of the Thames Basin was 1·60in., being 0·33 of an inch below the average mean rainfall for that month during the previous 38 years. The average daily natural flow of the Thames at Teddington Weir during the month was 481·9 million gallons, being 653·8 million gallons below the daily average for the 38 preceding years. The maximum daily flow was 753·1, and the minimum 260·3 million gallons.

APPARATUS FOR MANUFACTURE OF ETHER AND STRAY ELECTRIC CURRENTS.—The deterioration, often very considerable, of the leaden apparatus employed for the manufacture of crude ether is due, as we know, to the formation of electric currents. These are produced, for example, in the case when the worm is made of hard lead whilst the still is of soft lead. It has, in fact, been noted that with a hard lead cathode, a soft lead anode, and, as electrolyte, a mixture of alcohol and sulphuric acid, such as that utilised for manufacture of ether, an electric current is produced. At the ordinary temperatures, a current of 0·05 ampere, with a difference of potential of 0·1 to 0·2 volt has been noted: usually the current does not exceed 0·01 ampere. To decrease wear of the plant, a writer in the *Chemiker Zeitung* recommends the use of very pure lead. All parts of the plant must be made with lead of uniform composition. Finally, the plant should be connected with the ground in various points.—*Chimie et Industrie*, July, 1921.

NEW COMPANIES.

The under-mentioned particulars of New Companies recently registered are taken from the Daily Register compiled by JORDAN & SONS, LIMITED, Company Registration Agents, Chancery Lane, W.C.2.

J. P. DAWE & COMPANY, LIMITED.—(176465)—Registered August 25th, 1921. 81, Malden Road, Kentish Town, N.W. To carry on the business of Chemists and Druggists. Nominal Capital: £500 in 500 Shares of £1 each. Directors: R. J. P. Dawe, 35, Junction Road, Holloway, N.; Ada H. Dawe, 35, Junction Road, Holloway, N. Qualification of Directors: £1. Remuneration of Directors: To be voted by Company.

BURLINGTON INDUSTRIAL LABORATORIES, LIMITED.—(176443)—Registered August 24th, 1921. To carry on the business of Analytical, Consulting and Manufacturing Chemists. Nominal Capital: £1,000 in 1,000 Shares of £1 each. Directors: F. Goddard, 78, Pershore Road, Thornton Heath, Surrey; H. Elliott, 7, Crawford Avenue, Bolton, Lancashire. Qualification of Directors: £50. Remuneration of Directors: To be voted by Company.

TIMMIS & INGHAM, LIMITED.—(176453)—Registered August 24th, 1921. 102, High Road, Ilford. To carry on the business of Chemical Manufacturers and Dealers. Nominal Capital: £4,000 in 4,000 Shares of £1 each. *Directors: G. Ingham, 102, High Road, Ilford;* C. H. Cooper, 199, Balfour Road, Ilford (Permanent Directors). Remuneration of Directors: £312 per annum each Permanent Directors.

Roberts (Barking), Limited.—(176473)—Registered August 25th, 1921. Creekmouth, Barking, Essex. To carry on the business of Manufacturers and Dealers in Inks, Paints, Varnishes, Oils and Colours. Nominal Capital: £100 in 100 Shares of £1 each. Directors: R. W. Orrock, "Bleak House", Creekmouth, Barking (Managing Director and Chairman); H. P. Orrock, 51, Salisbury Avenue, Barking, E. Clarke, 8, Lady Margaret Road, Kentish Town, N.W. Qualification of Directors: £2. Remuneration of Directors: To be voted by Company.

New Patents.

This List is specially compiled for the *Chemical News* by Messrs. Rayner & Co., Registered Patent Agents, of 5, Chancery Lane, London, W.C.2., from whom all information relating to Patents, Trade Marks and Designs can be obtained gratuitously.

Latest Patent Applications.

21708—British Dyestuffs Corporation, Ltd.—Manufacture of soluble *acid colouring-matters and intermediate compounds for* manufacture thereof. August 16.

21881—Chemische Fabric Rhenania, o.—Process for manufacture of sulphur from sulphuretted hydrogen. August 17.

22027—Herzog, E.—Manufacture of sodium peroxide. August 19.

21763—Wolvekamp, M. E.—Alkali salts of oxidizied protalbinic and lysalbinic acid as stable protective colloids for mercury *compounds. August 16.*

21649—Varwerke, vorm. Meister, Lucrus and Bruuning—Process of preparing aliphatic dialkylaminoalkyl compounds August 15.

21852—Bate, S. C.—Manufacture of triarylmethane colouring matters.

Specifications published this Week.

167540—South Metropolitan Gas Co. and Parrish, P.—Manufacture of ammonium sulphides.

167555—Matheson, A.—Manufacture of alum and sulphate of alumina.

149667—Pfannenschmidt, P. L.—Acid chambers, acid towers, acid mains and similar arrangements.

Abstract Published this Week.

Hydrocarbons.—Patent No. 165452.—Mr. C. Weizmann, of 41, Campden House Road, Kensington and D. A. Legg, of 15, Sisters Avenue, North Side, Clapham Common, both in London, have obtained a Patent for an improved process for obtaining hydrocarbons of the naphthene series. They are prepared by polymerizing 2- or 3-butene or mixture thereof by means of anhydrous aluminium, chloride; the butene may be treated in the gaseous or liquefied condition and the polymerization may be effected at a low temperature, or at ordinary temperature under pressure.

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VOL. CXXIII, No. 3205.

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

EDINBURGH, 1921.

INAUGURAL ADDRESS OF THE PRESIDENT.

SIR T. EDWARD THORPE, C.B., D.Sc., Sc.D., LL.D., F.R.S., Hon. F.R.S. Edin.

(Concluded from p. 141).

THE valency of the elements, like their periodicity, is a consequence of the principle that equilibrium becomes unstable when there are more than eight electrons in the outer layer of the atom. For on this view the chemical combination between two atoms, A and B, consists in the electrons of A getting linked up with those of B. Consider an atom like that of neon, which has already eight electrons in its outer layer; it cannot find room for any more, so that no atoms can be linked to it, and thus it cannot form any compounds. Now take an atom of fluorine, which has seven electrons in its outer layer; it can find room for one, but only one, electron, so that it can unite with one, but not with more than one, atom of an element like hydrogen, which has one electron in the outer layer. Fluorine, accordingly, is monovalent. The oxygen atom has six electrons; it has, therefore, room for two more, and so can link up with two atoms of hydrogen: hence oxygen is divalent. Similarly nitrogen, which has five electrons and three vacant places, will be trivalent, and so on. On this view an element should have two valencies, the sum of the two being equal to eight. Thus, to take oxygen as an example, it has only two vacant places, and so can only find room for the electrons of two atoms; it has, however, six electrons available for filling up the vacant places in other atoms, and as there is only one vacancy to be filled in a fluorine atom the electrons in an oxygen atom could fill up the vacancies in six fluorine atoms, and thereby attach these atoms to it. A fluoride of oxygen of this composition remains to be discovered, but its analogue, SF_6, first made known by Moissan, is a compound of this type. The existence of two valencies for an element is in accordance with views put forward some time ago by Abegg and Bödlander. Prof. Lewis and Mr. Irving Longmuir have developed, with great ingenuity and success, the consequences which follow from the hypothesis that an octet of electrons surrounds the atoms in chemical compounds.

The term "atomic weight" has thus acquired for the chemist an altogether new and much wider significance. It has long been recognised that it has a far deeper import than as a constant useful in chemical arithmetic. For the ordinary purposes of quantitative analysis, of technology, and of trade, these constants may be said to be now known with sufficient accuracy. But in view of their bearing on the great problem of the essential nature of matter and on the "superlatively grand question: What is the inner mechanism of the atom?" they become of supreme importance. Their determination and study must now be approached from entirely new standpoints and by the conjoint action of chemists and physicists. The existence of isotopes has enormously widened the horizon. At first sight it would appear that we should require to know as many atomic weights as there are isotopes, and the chemist may well be appalled at such a prospect. All sorts of difficulties start up to affright him, such as the present impossibility of isolating isotopes in a state of individuality, their possible instability, and the inability of his quantitative methods to establish accurately the relatively small differences to be anticipated. All this would seem to make for complexity. On the other hand, it may eventually tend towards simplification. If, with the aid of the physicist we can unravel the nature and configuration of the atom of any particular element, determine the number and relative arrangement of the constituent protons and electrons, it may be possible to arrive at the atomic weight by simple calculation, on the assumption that the integer rule is mathematically valid. This, however, is almost certainly not the case, owing to the influence of "packing." The little differences, in fact, may make all the difference. The case is analogous to that of the so-called gaseous laws in which the departures from their mathematical expression have been the means of elucidating the physical constitution of the gases and of throwing light upon such variations in their behaviour as have been observed to occur. There would appear, therefore, ample scope for the chemist in determining with the highest attainable accuracy the departures from the whole-number rule, since it is evident that much depends upon their exact extent.

These considerations have already engaged the attention of chemists. For some years past, a small International Committee, originally appointed in 1903, has made and published an annual report in which they have noted such determinations of atomic weight as have been made during the year preceding each report, and they have from time to time made suggestions for the amendment of the Tables of Atomic Weights, published in text-books and chemical journals, and in use in chemical laboratories. In view of recent developments, the time has now arrived when the work of this International Committee must be reorganised and its aims and functions extended. The mode in which this should be done has been discussed at the meeting in Brussels, in June last, of the International Union of Chemistry Pure and Applied, and has resulted in strengthening the constitution of the Committee and in a wide extension of its scope.

The crisis through which we have recently passed has had a profound effect upon the world. The spectacle of the most cultured and most highly developed peoples on this earth, armed with every offensive appliance which science and the inventive skill and ingenuity of men could suggest, in the throes of a death struggle must have made the angels weep. That dreadful

harvest of death is past, but the aftermath remains. Some of it is evil, and the evil will persist for, it may be, generations. There is, however, an element of good in it, and the good, we trust, will develop and increase with increase of years. The whole complexion of the world—material, social, economic, political, moral, spiritual—has been changed, in certain aspects immediately for the worse, in others prospectively for the better. It behoves us, then, as a nation, to pay heed to the lessons of the war.

The theme is far too complicated to be treated adequately within the limits of such an address as this. But there are some aspects of it germane to the objects of this Association, and I venture, therefore, in the time that remains to me, to bring them to your notice.

The Great War differed from all previous internecine struggles in the extent to which organised science was invoked and systematically applied in its prosecution. In its later phases, indeed, success became largely a question as to which of the great contending parties could most rapidly and most effectively bring its resources to their aid. The chief protagonists had been in the forefront of scientific progress for centuries, and had accumulated experience of the manifold applications of science in practically every department of human activity that could have any possible relation to the conduct of the war. The military class in every country is probably the most conservative of all the professions and the slowest to depart from tradition. But when nations are at grips, and they realise that their very existence is threatened, every agency that may tend to cripple the adversary is apt to be resorted to—no matter how far it departs from the customs and conventions of war. This is more certain to be the case if the struggle is protracted. We have witnessed this fact in the course of the late War. Those who, realising that in the present imperfect stage of civilisation, wars are inevitable, and yet strove to minimise their horrors, and who formulated the Hague Convention of 1899, were well aware how these horrors might be enormously intensified by the applications of scientific knowledge, and especially of chemistry. Nothing shocked the conscience of the civilised world more than Germany's cynical disregard of the undertaking into which she had entered with other nations in regard, for instance, to the use of lethal gas in warfare. The nation that treacherously violated the Treaty of Belgium, and even applauded the action, might be expected to have no scruples in repudiating her obligations under the Hague Convention. April 25, 1915, which saw the clouds of the asphyxiating chlorine slowly wafted from the German trenches towards the lines of the Allies, witnessed one of the most bestial episodes in the history of the Great War. The world stood aghast at such a spectacle of barbarism. German *kultur* apparently had absolutely no ethical value. Poisoned weapons are employed by savages, and noxious gas had been used in Eastern warfare in early times, but its use was hitherto unknown among European nations. How it originated among the Germans—whether by the direct unprompted action of the Higher Command, or, as is more probable, at the instance of persons connected with the great manufacturing concerns in Rhineland, has, so far as I know, not transpired. It was not so used in the earlier stages of the War, even when it had become a war of position. It is notorious that the great chemical manufacturing establishments of Germany had been, for years previously, sedulously linked up in the service of the war which Germany was deliberately planning—probably, in the first instance, mainly for the supply of munitions and medicaments. We may suppose that it was the tenacity of our troops, and the failure of repeated attempts o dislodge hem by direct attack, that led to the employment of such foul methods. Be this as it may, these methods became part of the settled practice of our enemies, and during the three succeeeding years, that is from April, 1915, to September, 1918, no fewer than eighteen different forms of poison—gases, liquids, and solids—were employed by the Germans. On the principle of Vespasian's law, reprisals became inevitable, and for the greater part of three years we had the sorry spectacle of the leading nations of the world flinging the most deadly products at one another that chemical knowledge could suggest and technical skill contrive. Warfare, it would seem, has now definitely entered upon a new phase. The horrors which the Hague Convention saw were imminent, and from which they strove to protect humanity, are now, apparently, by the example and initiative of Germany, to become part of the established procedure of war. Civilisation protests against a step so retrograde. Surely comity among nations should be adequate to arrest it. If the League of Nations is vested with any real power, it should be possible for it to devise the means, and to ensure their successful application. The failure of the Hague Convention is no sufficient reason for despair. The moral sense of the civilised world is not so dulled but that, if roused, it can make its influence prevail. And steps should be taken without delay to make that influence supreme, and all the more so that there are agencies at work which would seek to perpetuate such methods as a recognised procedure of war. The case for what is called chemical warfare has not wanted for advocates. It is argued that poison gas is far less fatal and far less cruel than any other instrument of war. It has been stated that "amongst the 'mustard gas' casualties the deaths were less than 2 per cent, and when death did not ensue complete recovery generally utimately resulted. . . . Other materials of chemical warfare in use at the Armistice do not kill at all; they produce casualties which, after six weeks in hospital, are discharged practically without permanent hurt." It has been argued that, as a method of conducting war, poison-gas is more humane than preventive medicine. Preventive medicine has increased the unit dimension of an army, free from epidemic and communicable disease, from 100,000 men to a million. "Preventive medicine has made it possible to maintain 20,000,000 men under arms and abnormally free from disease, and so provided greater scope for the killing activites of the other military weapons. . . . Whilst the surprise effects of chemical warfare aroused anger as being contrary to military tradition, they were minute compared with those of preventive medicine. The former slew in its thousands, whilst the latter slew its millions and is still reaping the harvest." This argument carries no conviction. Poison gas is not

merely contrary to European military tradition; it is repugnant to the right feeling of civilised humanity. It in no wise displaces or supplants existing instruments of war, but creates a new kind of weapon, of limitless power and deadliness. 'Mustard gas' may be a comparatively innocuous product as lethal substances go. It certainly was not intended to be such by our enemies. Nor, presumably, were the Allies any more considerate when they retaliated with it. Its effects indeed, were sufficiently terrible to destroy the German *moral*. The knowledge that the Allies were preparing to employ it to an almost boundless extent was one of the factors that determined our enemies to sue for the Armistice. But if poisonous chemicals are henceforth to be regarded as a regular means of offence in warfare, is it at all likely that their use will be confined to 'mustard gas,' or indeed to any other of the various substances which were employed up to the date of the Armistice? To one who, after the peace, inquired in Germany concerning the German methods of making 'mustard gas,' the reply was:—'Why are you worrying about this when you know perfectly well that this is not the gas we shall use in the next war?'"

I hold no brief for preventive medicine, which is well able to fight its own case. I would only say that it is the legitimate business of preventive medicine to preserve by all known means the health of any body of men, however large or small, committeed to its care. It is not to its discredit if, by knowledge and skill, the numbers so maintained run into millions instead of being limited to thousands. On the other hand, "an educated public opinion" will refuse to give credit to any body of scientific men who employ their talents in devising means to develop and perpetuate a mode of warfare which is abhorrent to the higher instincts of humanity.

This Association, I trust, will set its face against the continued degradation of science in thus augmenting the horrors of war. It could have no loftier task than to use its great influence in arresting a course which is the very negation of civilisation.

THE LABORATORY OF THE LIVING ORGANISM.

Address Delivered before Section B (Chemistry)

By M. O. Forster, D.Sc., F.R.S., President of the Section.

Many and various are the reasons which have been urged, at different periods of its history, for stimulating the study of chemistry. In recent years these have been either defensive or frankly utilitarian, in the latter feature recalling the less philosophic aspects of alchemy; moreover, it is to be feared that a substantial proportion of those who have lately hastened to prepare themselves for a chemical career have been actuated by this inducement. It is the duty, therefore, of those who speak with any degree of experience to declare that the only motive for pursuing chemistry which promises anything but profound disappointment is an affection for the subject sufficiently absorbing to displace the attraction of other pursuits. Even to the young chemist who embarks under this inspiration the prospect of success as recognised by the world is indeed slender, but, as his knowledge grows and the consequent appreciation of our ignorance widens, enthusiasm for the beauty and mystery of surrounding nature go far in compensating for the disadvantages of his position. On the other hand, he who has been beguiled into embracing chemistry on the sole ground of believing it to be a "good thing" will either desert it expeditiously or almost surely starve and shower purple curses upon his advisers.

In one respect chemistry resembles measles—every boy and girl should have it, lest an attack in later life should prove more serious. Moreover, whilst it is not only unnecessary, but most undesirable, to present the subject as if every boy and girl were going to be a chemist, it is most important to present it in such a manner that every educated citizen may realise the intimate part which chemistry plays in his daily life. Not only do chemical principles underlie the operations of every industry, but every human being—indeed, every living plant and animal—is, during each moment of healthy life, a practical organic and physical chemist, conducting analytical and synthetical processes of the most complex order with imperturbable serenity. No other branch of knowledge can appeal for attention on comparable grounds; and without suggesting that we should all, individually, acquire sufficient chemical understanding fully to apprehend the changes which our bodies effect so punctually and so precisely—for this remains beyond the power of trained chemists—it may be claimed that an acquantaince with the general outlines of chemistry would add to the mental equipment of our people a source of abundant intellectual pleasure which is now unfairly denied them. We have been told that the world shall be made a fit place for heroes to live in; but is not the preliminary to this ideal an exposition to those heroes of the wonder and beauty of the world which they already occupy, on the principle that if you cannot have what you like, it is elementary wisdom to like what you have? In following the customary practice of surveying matters of interest which have risen from our recent studies, therefore, it is the purpose of this address to emphasise also those æsthetic aspects of chemistry which offer ample justification for the labour which its pursuit involves.

What is breakfast to the average man? A hurried compromise between hunger and the newspaper. How does the chemist regard it? As a daily miracle which gains, rather than loses, freshness as the years proceed. For just think what happens. Before we reach the table, frizzled bacon, contemplated or smelt, has actuated a wonderful chemical process in our bodies. The work of Pavlov has shown that if the dog has been accustomed to feed from a familiar bowl the sight of that bowl, even empty, liberates from the appropriate glands a saliva having the same chemical composition as that produced by snuffing the food. This mouth-watering process, an early experience of childhood, is known to the polite physiologist as a "psychic reflex," and the various forms assumed by psychic reflex, responding to the various excitations which arise in the daily life of a human

being, must be regarded by the chemical philosopher as a series of demonstrations akin to those which he makes in the laboratory, but hopelessly inimitable with his present mental and material resources. For, extending this principle to the other chemical substances poured successively into the digestive tract, we have to recognise that the minute cells of which our bodies are co-ordinated assemblages possess and exercise a power of synthetic achievement contrasted with which the classical syntheses, occasionally enticing the modern organic chemist to outbursts of pride, are little more than hesitating preliminaries. Such products of the laboratory, elegant as they appear to us, represent only the fringe of this vast and absorbing subject. Carbohydrates, alkaloids, glucosides, and purines, complex as they seem when viewed from the plane of their constituent elements, are but the molecular debris strewing the path of enzyme action and photochemical synthesis, whilst the enzymes produced in the cells, and applied by them in their ceaseless metamorphoses, are so far from having been synthesised by the chemist as to have not even yet been isolated in purified form, although their specific actions may be studied in the tissue-extracts containing them.

Reflect for a moment on the specific actions. The starch in our toast and porridge, the fat in our butter, the proteins in our bacon, all insoluble in water, by transformations otherwise unattainable in the laboratory are smoothly and rapidly rendered transmissible to the blood, which accepts the products of their disintegration with military precision. Even more amazing are the consequences. Remarkable as the foregoing analyses must appear, we can dimly follow their progress by comparison with those more violent disruptions of similar materials revealed to us by laboratory practice, enabling such masters of our craft as Emil Fischer to isolate the resultant individuals. Concurrently with such analyses, however, there proceeds syntheses which we can scarcely visualise, much less imitate. The perpetual elaboration of fatty acids from carbohydrates, of proteins from amino-acids, of zymogens and hormones as practised by the living body are beyond the present comprehension of the biochemist; but their recognition is his delight, and the hope of ultimately realising such marvels provides the dazzling goal towards which his efforts are directed.

The Vegetable Alkaloids.

The joyous contemplation of these wonders is an inalienable reward of chemical study, but it is denied to the vast majority of our people. The movements of currency exchange, to which the attention of the public has been directed continuously for several years, are clumsy contortions within the mental horizon of those who take pleasure in study and reflection; and to those also the distinction between plants and animals should be at least intelligible. The wonderful power which plants exercise in building up their tissues from carbonic acid, water, and nitrogen, contrasted with the powerlessness of animals to utilise these building materials until they have been already assembled by plants, is a phenomenon too fundamental and illuminating to be withheld, as it now is, from all but the few. For by its operation the delicate green carpet, which we all delight in following through the annual process of covering the fields with golden corn, is accomplishing throughout the summer months a vast chemical synthesis of starch for our benefit. Through the tiny pores in those tender blades are circulating freely the gases of the atmosphere, and from those gases—light, intangible nothingness, as we are prone to regard them—this very tangible and important white solid compound is being elaborated. The chemist cannot do this. Plants accomplish it by their most conspicuous feature, greenness, which enables then to put solar energy into cold storage; they are accumulating fuel for subsequent development of bodily heat energy. Side by side with starch, however, these unadvertised silent chemical agencies elaborate molecules even more imposing, in which nitrogen is interwoven with the elements of starch, and thus are produced the vegetable alkaloids.

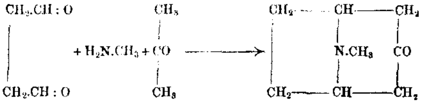


Fig. 1.

In this province the chemist has been more fortunate, and successive generations of students have been instructed in the synthesis of piperine, coniine, trigonelline, nicotine and extensions from the artificial production of tropine; but until quite recently his methods have been hopelessly divergent from those of the plant. Enlightening insight into these, however, was given just four years ago by R. Robinson, who effected a remarkably simple synthesis of tropinone by the mere association of succindialdehyde, methylamine, and acetone in water, unassisted by a condensing agent or an increase of temperature (see Fig. 1).

Although the yield was very small, it reached 42 per cent when acetone was replaced by a salt of its dicarboxylic acid, which might easily arise from citric acid as one of the itermediate compounds used by plants in their synthetical exercises.

Based upon this experiment, R. Robinson (1917) has developed an attractive explanation of the phytochemical synthesis of alkaloids, in which the genesis of a pyrrolidine, piperidine, quinuclidine, or *iso*-qninoline group is shown to be capable of proceeding from the association and interaction of an amino-acid, formaldehyde, acetonedicarboxylic acid and the intermediate

be fair to the resourceful skill embodied in this theory to attempt an abbreviated description of the methods by which molecules as complex even as those of morphine and narcotine may be developed. Ornithine ($\alpha\delta$-diaminovaleric acid) is represented as the basis of hygrine, cuschygrine, and the tropine alkaloids, whilst the coniine group may spring from lysine ($\alpha\epsilon$-diaminocaproic acid). A particularly interesting application of these principles has been made with reference to the vital synthesis of harmine, which W. H. Perkin and R. Robinson (1919) represent as *arising from a hydroxytryptophan as yet undiscovered*; meanwhile they have shown that barman is identical with the base obtained by Hopkins and Cole on oxidising tryptophan itself with ferric chloride. Thus it may be claimed that Robinson's *theory represents a notable advance in our conception* of these vital changes, and that by means of the carbinolamine and aldol condensations involved fruitful inquiries into constitution and the mechanism of synthesis will follow.

The Nucleic Acids.

Owing to the venerable position occupied by *alkaloids in the systematic development of chemical* science, and to the success which has attended elucidation of their structure, many of us have become callous to the perpetual mystery of their elaboration. Those who seek fresh wonders, however, *need only turn to the nucleic acids in* order to satisfy their curiosity. For in the nucleic acid of yeast the chemist finds a definite entity forming a landmark in the path of metabolic procedure, a connecting link between the undefined molecules of living protein and the crystallisable products of katabolic disintegration.

Let us review this remarkable substance. With an empirical formula, $C_{38}H_{49}O_{29}N_{15}P_4$, it has a molecular weight (1303) exceeding that of the octadecapeptide (1213) synthesised by Fischer (1907), although considerably below those of the *penta-(penta-acetyl-m-digalloyl)-β-glucose* (2136) produced by Fischer and Bergmann (1918), and of the hepta-(tribenzoylgalloyl)-*p*-iodophenylmaltosazone (4021) elaborated by Fischer and Freudenberg (1912). Nevertheless, its intrinsic importance *is transcendent. In the language of chemistry* it is a combination of four nucleotides, linked with one another through the pentose molecule, *d*-ribose, which is common to each, and owing its acid character to phosphoric acid, also common to the component nucleotides. *The latter differ from* one another in respect of their nitrogenous factors, which are guanine (2-amino-6-oxypurine), adenine (6-aminopurine), uracil (2 : 6-dioxypyrimidine), and cytosine (2-oxy-6-aminopyrimidine), giving their names to the four nucleotides linked with each other in the following manner:

$$(HO)_2PO.O.C_5H_7O_2.C_5H_4ON_5 \qquad \text{(guanine)}$$
$$|$$
$$O$$
$$|$$
$$(HO)_2PO.O.C_5H_6O.C_4H_4ON_3 \qquad \text{(cytosine)}$$
$$|$$
$$O$$
$$|$$
$$(HO)_2PO.O.C_5H_6O.C_5H_4N_5 \qquad \text{(adenine)}$$
$$|$$
$$O$$
$$|$$
$$(HO)_2PO.O.C_5H_7O_2.C_4H_3O_2N_2 \qquad \text{(uracil)}$$

We owe this picture of plant nucleic acid to the combined researches of many chemists, conspicuous amongst whom is A. Kossel; *he derived* purine bases from nucleins in the early eighteen-eighties, and subsequently identified the products of completely hydrolysing the nucleic acids from yeast and from the thymus gland. Characterisa*tion of intermediate products in such hydrolyses*—namely, the nucleotides of guanine, cytosine, adenine, and uracil—with the corresponding nucleosides, guanosine, cytidine, adenosine, and uridine, is due chiefly to W. Jones and to P. A. Levene, with who was later associated W. A. Jacobs; but the most picturesque of all contributions to the subject was made by the earliest of the systematic investigators, Friedrich Miescher, who followed his isolation of nuclein (nucleic acid) *from pus cells* (1868) by the *remarkable discovery* that the spermatozoa heads of Rhine salmon consist almost entirely of protamine nucleate (1874), and that this must have arisen, not directly from food, but from muscle protein.

Whilst the yeast cell and the wheat embryo have the power to synthesise nucleic acid of the structure represented above, the thymus gland elaborates another nucleic acid in which a hexose is substituted for *d*-ribose, and uracil is replaced by thymine, its methyl derivative (5-methyl-2 : 6-dioxypyrimidine); the order and mode of nucleotide linkage are also different. These nucleic acids, although deriving their carbohydrate and phosphoric acid from the nourishment on which the organism thrives, do not owe the purine factors to the same source; in other words, the tissues must have power to synthesise a purine ring. The mechanism by which they exercise this power is one of the many problems which await elucidation but arginine (α-amino-δ-guanidinevaleric acid) has been indicated as one possible origin, whilst histidine (α-amino-β-imidazolylpropionic acid) may be a source of the pyrimidine nucleus.

The transformations undergone by nucleic acid in contact with tissue-extracts have provided the *subjects of numerous investigations extending* over thirty years. In fact, the experimental materials of such voluminous complexity as to be unintelligible without the guidance of an expert, and in this capacity W. Jones has rendered *valuable service by his recent lucid arrangement* of the subject (1921). From this it is comparatively easy to follow the conversion of nucleic acid into uric acid through the agency of enzymes, and a review of these processes can only serve to increase our admiration for the precision and facility with which the chemical operations of the living body are conducted. Regarding for the sake of simplicity only the purine nucleotides, these are probably the first products of hydrolysing nucleic acid, and from them there may be liberated either phosphoric acid by a phosphonuclease, or the purine-base by a purine-nuclease, giving rise to guanine and adenine, with their nucleosides, guanosine and adenosine. Thereafter the procedure is less obscure. The four products exchange their amino-group for hydroxyl under *the influence of their respective deaminase* —namely, guanase, adenase, guanosine-deaminase or adenosine-deaminase. The two original nucleosides, with their corresponding derivatives, xanthosine and inosine, are then hydrolysed by

their appropriate hydrolase, and the resulting oxypurines, xanthine and hypoxanthine, are further oxidised by xanthine-oxidase to uric acid. This is the concluding phase of purine metabolism in man and apes, but other animals are able to transform uric acid into allantoin by means of uricase. The changes may be represented diagrammatically (see Fig. 2).

Considerable progress has been made also in localising the various enzymes among the organs of the body, particularly those of animals. Into the results of these inquiries it is not the purpose of this address to enter further than to indicate that they reveal a marvellous distributon, throughout the organism, of materials able to exert at the proper moment those chemical activities appropriate to the changes which they are required to effect. The contemplation of such a system continuously, and in health unerringly, completing a series of chemical changes so numerous and so diverse, must produce in every thoughtful mind a sensation of humble amazement. The aspect of this miraculous organisation which requires most to be emphasised, however, is that an appreciation of its complex beauty can be gained only by those to whom at least the elements of a training in chemistry have been vouchsafed. Such training has potential value from an ethical standpoint, for chemistry is a drastic leveller; in the nucleic acids man discovers a kinship with yeast-cells, and in their common failure to transform uric acid into allantoin he finds a fresh bond of sympathy with apes. The overwhelming majority of people arrive at the grave, however, without having had the slightest conception of the delicate chemical machinery and the subtle physical changes which, *throughout each moment of life, they have* methodically and unwittingly operated.

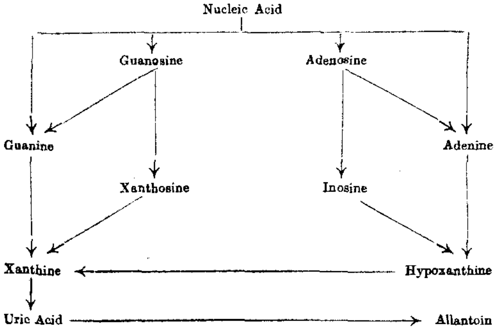


Fig. 2.

Chlorophyll and Hæmoglobin.

To those who delight in tracing unity among the bewildering intricacies of natural processes, and by patient comparison of superficially dissimilar materials triumphantly to reveal continuity in the discontinuous, there is encouragement to be found in the relationship between chlorophyll and hæmoglobin. Even the most detached and cynical observer of human failings must glow with a sense of worship when he perceives this relationship, and thus brings himself to acknowledge the commonest of green plants among his kindred. Because, just as every moment of his existence depends upon the successful performance of its chemical duties by the hæmoglobin of his blood corpuscles, so the life and growth of green plants hinge on the transformations of chlorophyll.

The persevering elucidation of chlorophyll structure ranks high in the achievements of modern organic chemistry, and in its later stages is due principally to Willstätter and his collaborators, whose investigations culminated in 1913. Eliminating the yellow and colourless companions of the substance by a regulated system of partition among solvents, they raised the chlorophyll content to 70 per cent from the 8 to 16 per cent found in the original extract, completing the separation by utilising the insolubility of chlorophyll in petroleum ether. By such means, 1 kilogrm. of dried stinging-nettles gave 6·5 grms. of the purified material, representing about 80 per cent of the total amount which the leaf contains, and application of the process to fresh leaves has established the identity of the product from both sources. Thus the isolation of chlorophyll from plants is now no more difficult than that of alkaloids or of sugars, and may actually be demonstrated as a lecture-experiment.

As a consequence of these operations, the dual nature of leaf-green was brought to light in 1912. The focus of main phytochemical action is thus revealed as a system composed of chlorophyll-*a*, *bluish-green in solution, and of the yellowish-*green chlorophyll-*b*, representing different stages of oxidation as indicated by the formulæ,

(*a*) $C_{32}H_{30}ON_4Mg(CO_2.CH_3)\ (CO_2.C_{20}H_{39}) = C_{55}H_{72}O_5N_4Mg$

(*b*) $C_{32}H_{28}O_2N_4Mg(CO_2.CH_3)\ (CO_2.C_{20}H_{39}) = C_{55}H_{70}O_6N_4Mg$

In the solid form these products are micro-crsytalline powders, bluish-black and greenish-black respectively. They are accompanied by two non-nitrogenous yellow pigments, the unsaturated hydrocarbon, carrotene, $C_{40}H_{56}$, and its oxide, xanthophyll, $C_{40}H_{56}O$, both of which readily absorb oxygen and are allied to a third carrotinoid substance, fucoxanthin, $C_{40}H_{56}O_6$, associated with them in brown algæ and isolated in 1914. Based upon the experience indicated above, Willstätter and his colleagues have examined upwards of 200 plants drawn from numerous classes of cryptogams and phanerogams. The leaf-green of these is identical, and the proportion of *a* to *b* almost invariably approaches 3 : 1 excepting in the brown algæ, in which *b* is scarcely recognisable.

This is not an occasion to follow, otherwise than in the barest outline, the course of laboratory disintegration to which the chlorophyll molecules have been subjected by the controlled attack of alkalis and acids. The former agents reveal chlorophyll in the twofold character of a lactam and a dicarboxylic ester of methyl alcohol and phytol, an unsaturated primary alcohol, $C_{20}H_{39}.OH$, of which the constitution remains obscure in spite of detailed investigation of its derivatives; but the residual complex, representing two-thirds of the original molecule, has been carefully dissected. The various forms of this basic principle also of the blood-pigment, in which iron plays the part of magnesium in chlorophyll. *Fundamental as is the difference between hæmoglobin* and chlorophyll, relationship can be claimed through this connecting-link, because the same compound, ætioporphyrin has been produced from hæmoporphyrin, $C_{33}H_{36}O_4N_4$, which is thus its dicarboxylic acid. Hæmoporphyrin arises from hæmatoporphyrin, $C_{33}H_{38}O_6N_4$, produced by the action of hydrobromic acid on hæmin, $C_{33}H_{32}O_4N_4FeCl$, which in turn is derived by exchanging chlorine for hydroxyl in hæmatin, $C_{33}H_{33}O_5N_4Fe$, the non-albuminoid partner of globin in hæmoglobin. Thus, omitting many intermediate stages, the relationship between chlorophyll and hæmoglobin may be sketched by the diagram (see Fig. 3).

It must be remembered, however, that although recent years have witnessed great progress in elucidating the nature of chlorophyll and hæmoglobin, the mechanism by which they act remains unrevealed. The famous assimiliation hypothesis of von Baeyer, according to which it is formaldehyde which represents the connecting link in the phytochemical synthesis of carbohydrate from carbon dioxide, was enunciated in 1870, and arose from Butlerow's preparation of methylenitan. In spite of numerous criticisms, some of which are quite recent, it remains unshaken. The line of

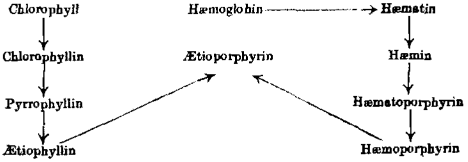
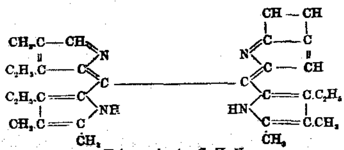


FIG. 3.

residual complex, when produced by the action of alkalis on chlorophyll, have been called "phyllins"; they are carboxylic acids of nitrogenous ring-systems, which retain magnesium in direct combination with nitrogen. The porphyrins are the corresponding products arising by the action of acids; they are carboxylic acids of the same nitrogenous ring-systems from which the magnesium has been removed. The phyllins and the porphyrins have alike been degraded to the crystalline base, ætioporphyrin, $C_{31}H_{36}N_4$, into the composition of which four variously substituted pyrrole rings enter, probably as follows:



Ætioporphyrin, $C_{31}H_{36}N_4$.

It is this assemblage of substituted pyrroles which, according to present knowledge, is the such criticism has taken two directions. Of the one hand, H. A. Spoehr (1913), from experiments suggested by the fact that the morning acidity of plant juices diminshes or disappears on exposure to light, has shown that this change is photochemical only, and may be independent of enzymes, the volatile products including formaldehyde. Emil Baur (1908, 1910, and 1913) has urged the claims of oxalic acid to be regarded as the first product of assimilation, and shews how this may lead to the other plant-acids, glycollic, malic, and citric, the first-named being a possible stepping-stone to the carbohydrates by resolution into formaldehyde (and formic acid), incidentally assuming towards malic and citric acids the relationship which glucose bears to starch. On the other hand, K. A. Hofmann and Schumpelt (1916) preceded by Bredig (1914), have attacked the hypothesis on the ground of kinetics, and imagine an electrolytic resolution of water under the influence of light, which liberates oxygen and effects the reduction of carbon dioxide by hydrogen to formaldehyde through formic acid.

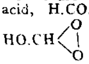
All these arguments have been weighed by Willstätter and Stoll (1917), who dismiss them on comparing the volume of carbon dioxide absorbed by leaves with the correspond-

ing volume of oxygen liberated. They point out that this assimilatory quotient, CO_2/O_2, which should be unity in the case of formaldehyde, becomes 1·33, 2 and 4 in the case of glycollic, formic, and oxalic acids respectively. Proceeding to determine this quotient experimentally, they found it to be unity, whether the temperature is 10° or 35°, whether the atmosphere is rich in carbon dioxide or free from oxygen, and alike with ordinary foliage or cactus. Furthermore, they found (1917) that whilst organic liquids holding chlorophyll in solution do not absorb more carbon dioxide than the liquids themselves, this gas is absorbed much more freely by chlorophyll hydrosols than by other colloidal solutions, a maximum assimilation of two molecular proportions to one magnesium atom being reached, when phæophytin is precipitated :—

$$C_{55}H_{72}O_5N_4Mg+2CO_2+2H_2O= C_{55}H_{74}O_5N_4+Mg(HCO_3)_2.$$

Prior to this change, which is the first stage appearing in a controlled disruption of chlorophyll-*a* by mineral acids, there is produced an intermediate compound resembling a hydrogen carbonate in which the metal retains a partial grip on the nitrogen (see Fig. 4).

It is suggested that leaf-green unites with carbon dioxide by similar mechanism, and that the action of light on the above compound transforms the carbonic acid into an isomeride having the nature of a peroxide such as per-formic acid, H.CO.O.OH, or formaldehyde peroxide,



Anthocyans, the Pigments of Blossoms and Fruits.

Since the days of Eden, gardens have maintained and extended their silent appeal to the more gentle emotions of mankind. The subject possesses a literature, technical, philosophical, and romantic, at least as voluminous as that surrounding any other industrial art, and the ambition to cultivate a patch of soil has attracted untold millions of human beings. Amongst manual workers none maintain a standard of orderly procedure and patient industry higher than that of the gardener. Kew and La Mortola defy the power of word-painters to condense their soothing beauty into adequate language, whilst that wonderful triangle of cultivation which has its apex at Grasse almost might be described as industry with a halo.

To the countless host of flower-lovers, however, it is probable that Grasse is the only connecting-link between chemistry and their cherished blossoms, they being dimly aware that the ingredients of some natural perfumes have been imitated in the laboratory. The circumstance that identical products of change are generated by the plant, however, and form but one section of the numberless chemical elaborations which proceed before their eyes escapes them because it has been ordained that chemistry is to occupy a backwater in the flood of knowledge. Let us hope that before another century has passed this additional charm to the solace of a garden may be made more generally accessible.

Even to chemists it is only during the last decade that the mechanism of blossom-chemistry has been revealed. The subject has indeed excited their attention since an early period in the history of the organic branch, and the existing class-name for blossom-pigments was first used by Marquart in 1835 to distinguish blue colouring-matters occurring in flowers. It is also interesting to us to notice that in the following year Dr. Hope, who presided over the birth of the Chemistry Section at the Edinburgh meeing in 1834, described experiments conducted with blossoms representing many different orders, and devised a classification of the pigments which they contain. The recognition of glucosides amongst the anthocyans appears to have been first made as recently as 1894, by Heise; about that period, also, it gradually became clear that the various colours assumed by flowers are not variations of a single substance common to all, but arise from a considerable number of non-nitrogenous pigments. Prior to 1913, the most fruitful attempt to isolate a colouring-matter from blossoms in quantity sufficient for detailed examination had been made by Grafe (1911), but the conclusions to which it led were inaccurate. In the year mentioned, however, Willstätter began to publish with numerous collaborators a series of investigations, extending over the next three years, which have brought the subject within the realm of systematic chemistry. For the purpose of distinguishing glucosidic and non-glucosidic anthocyans the names anthocyanin and anthocyanidin respectively were applied. The experimental separation of anthocyanins from anthocyanidins was effected by partition between amyl alcohol and dilute mineral acid, the latter retaining the diglucosidic anthocyanins in the form of oxonium salts and leaving the anthocyanidins quantitatively in the amyl alcohol, from which they are not removed by further agitation with dilute acid; the monoglucosidic anthocyanins were found in both media, but left the amyl alcohol when offered fresh portions of dilute acid.

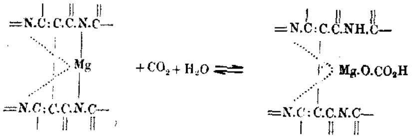


FIG. 4.

(To be continued).

THE ACTION OF AMMONIUM HYDRATE UPON MERCUROUS CHLORIDE.

By J. G. F. DRUCE, M.Sc., A.I.C.

When ammonium hydrate is added to insoluble mercurous chloride, the white solid is converted into "black precipitate" of the formula NH_2Hg_2Cl. The equation representing this reaction is usually given as:—

$$NH_4OH+Hg_2Cl_2=NH_2Hg_2Cl+H_2O+HCl.$$

This suggests that on mixing the reactants, one of which is neutral and the other is alkaline to indicators, the resultant products should react acid. Actually, it is found that this is not the case, and it was thought desirable to ascertain whether the hydrochloric acid represented as being formed was immediately neutralised by excess of ammonium hydrate.

This appears to be the correct view, since however little of the alkali is used, only one-half of it is accounted for by the above equation, which only represents an initial reaction. The hydrochloric acid produced is only momentarily free; it is immediately neutralised by a second equivalent of ammonium hydrate.

Quantitative experiments have been carried out to elucidate the nature of the reaction as follows.

Mercurous chloride (0·942 grm.) was placed in a conical flask of 200 cc. capacity, and shaken with 10 cc. of water. 20 cc. of a normal solution of ammonium hydrate were added, and the whole was shaken, after inserting a stopper, and allowed to stand for 15 hours. The mixture still evolved the odour of ammonia, and was quickly filtered into a graduated flask (200 cc.), and the precipitate was washed several times with water. The volume of filtrate and washings was made up to 200 cc. 20 cc. were withdrawn and titrated against a decinormal solution of hydrochloric acid. This was repeated twice. The 20 cc. of filtrate required:—

Expt.	cc. $\frac{N}{10}$ HCl
1	8·00
2	7·90
3	7·95
Mean	7·95

Thus the free ammonium hydrate in the total filtrate was 0·556 grm. The quantity actually taken was 0·700 grm., therefore 0·144 grm. was used in the course of the reaction. The amount of soluble chloride ions formed was estimated as follows:—

20 cc. of the filtrate made up to 200 cc. were withdrawn and boiled for 15 minutes to drive off all free ammonia. The residual solution was then titrated with a fiftieth normal solution of silver nitrate, using potassium chromate as indicator. This was also repeated twice, and the following results were obtained.

Expt.	cc. $\frac{N}{50}$ $AgNO_3$
1	9·20
2	9·15
3	9·10
Mean	9·15

Thus there was 0·098 grm. of ammonium chloride in the whole solution.

These results are accurately expressed by the equation:—

$$2NH_4OH+Hg_2Cl_2=NH_2Hg_2Cl+NH_4Cl+H_2O$$

which requires that for 0·942 grm. of mercurous chloride, 0·140 grm. of ammonium hydrate should be used and 0·107 grm. of ammonium chloride should be obtained.

A difference of opinion exists regarding the nature of the black precipitate NH_2Hg_2Cl. Some chemists consider it to be a mixture of white precipitate, NH_2HgCl and metallic mercury. If it is rubbed on to copper it does not amalgamate or perceptibly affect this metal. This is hardly to be expected if free mercury were present. Hence it seems more correct to regard the subtsance as a compound and not a mixture.

CHEMICAL NOTICES FROM FOREIGN SOURCES.

Comptes Rendus Hebdomadaires des Séances de l'Academie des Sciences. Vol. clxxiii., No. 7.

"Influence of Temperature on the Viscosity of Normal Liquids."—By M. Edm. van Aubel.

"Dimensions of the Molecules of some Fatty Oils, and on some Phenomena of Molecular Solutions."—By. M. Paul Woog.

No. 8.

"Depolarisation of Light by Liquids Holding in Suspension Crystalline Particles."—By M. St. Procopin.

No. 9

"Newton's Law and Einstein's Formula for the Perihelion of Planets."—By M. Gaston Bertrand.

NOTES.

The Registrar of the Institute of Chemistry has directed attention to an erroneous statement in Part IV. of the *Journal* of the Institute, to the effect that Dr. P. C. C. Isherwood had been appointed to a Lectureship in the University of Cambridge. Dr. Eric K. Rideal is Humphrey Owen Jones Lecturer in Physical Chemistry, and Dr. P. C. C. Isherwood is a Director of Messrs. W. J. Bush & Co. Ltd.

A scheme is afloat for "fertilising the air" to encourage plant growth. Experiments have been described by Dr. Gradenwitz, of New York. Various plants and vegetables were grown in an atmosphere artificially enriched with carbonic acid, and it is stated that an increased yield was obtained of spinach 150 per cent, potatoes 180 per cent, lupines 174 per cent, parsley 100 per cent.

Much interesting work is said to have been done, and further particulars may be obtained from Messrs. Wiskemann Smith & Co. Ltd., London, E.C.2.

Messrs. Siemens Bros. & Co. have equipped an extensive factory for the production of ebonite. From an advance proof of a new catalogue which we have just received, it is evident that the firm are manufacturing ebonite in all the forms used in the arts, both in the rough as tube, sheet, and block, and also in innumerable forms as finished articles, from high tension insulators to the mouthpieces of pipes. They are also introducing a new high-class insulating material under the name of "Keramot," which, judging from the claims made as its properties, is likely to find an extensive use in the electrical world.

The Polytechnic, Regent Street, London.—A course in Electrical Engineering has been arranged for the coming Session under the direction of Mr. Philip Kemp, M.Sc., Tech.M.I.E.E., and a competent staff. The courses, including Electrical engineering and subsidiary subjects, are arranged in various grades, and students are strongly recommended to avail themselves of these. In the first two years a student spends one evening per week in the Electrical Engineering Department, and two evenings per week in the succeeding years. At the close of the session examinations will be held in all stages, and students are expected to pass these examinations before proceeding to a more advanced class in the following year. Laboratory and home work are taken into consideration in determining a student's position. A silver medal may be awarded to the best student in the department, and bronze medals may be awarded to the best student in each year. Diplomas are awarded to students who have satisfactorily passed through the complete five year's course (including subsidiary subjects). Students are also prepared for the Final C. and G. and A.M.I.E.E. Examinations. The Electrical Laboratory is well equipped with various types of modern machinery and apparatus. The plant includes D.C. motors and generators, alternators, A.C. motors of the synchronous, induction, and single-phase commutator types, rotary converters, transformers, and mercury arc rectifier—totalling about 50 machines. A wireless aerial is erected upon the roof of the building. The department possesses an Electrical Library which is available for the use of students during laboratory classes.

Institute of Brewing.—The Research Committee of this Institute (Brewers Hall, Addle Street, London, E.C.2) are carrying out a series of investigations on hop growing and preparation. Recently an invitation was given to a number of the more prominent hop growers to visit the Research Station and the Gardens of Messrs. Whitbread, and a profitable day was spent in examining the progress of the investigations. Messrs. Whitbread & Co. are erecting experimental kilns for systematic work on drying and preparation. Experiments are in progress with a view to studying the effect of varying temperatures with constant air current; variation air current with constant temperature; the influence of the moisture content of the hops; the effect of burning varying amounts of sulphur; the effect of products of combustion of open fires, etc. The Secretary of the Institute is Mr. W. H. Bird, who will give any further information on the subject.

Argentina State Railway Requirements.—A telegram from the Commercial Secretary to His Majesty's Legation at Buenos Aires states that the State Railways are inviting tenders for one year's supply of he following: chemicals (close October 17); paints and varnishes (close October 18); foundry materials (close October 19th); metals (close October 20th); electrical stores (close October 21); glass (close October 24). Tenders must be presented through a local agent, but it will be preferable to quote local merchants. A copy of the relative specifications cannot be expected in the Department of Overseas Trade before the arrival of the ordinary mail at the end of September.

Calcutta Motor Show.—H.M. Trade Commissioner reports that, by the decision of the Motor Traders' Association, the Calcutta Motor Show (to be held from December 19 to 24) will be open to all except ex-enemy countries.

Lemberg Fair.—With reference to the Lemberg Fair, preliminary notice of which was published in the *Journal* of July 7, the Department of Overseas Trade is informed that the dates for the Fair have been fixed for September 25 to October 5. The classes of exhibits include machinery, iron work, technical supplies, oil industry, metallurgy, textiles, agricultural and agricultural implements, transport, furniture, building material, hides and leather goods, china, &c., paper, photography, sports goods, chemical goods, lighting apparatus, food products, musical instruments, and propaganda. Enquiries regarding space, &c., should be addressed to Targi Wschodnie (Eastern Fairs and Market, Ltd.), Lwow, Poland.

An Exhibition Afloat.—According to present plans, a specially designed Exhibition Ship, under the title of *British Industry*, will set sail from the Thames in the summer of 1923, for the chief ports of the world. A company called the British Trade Ship, Ltd., has been formed, with registered offices at 12, Grosvenor Gardens, S.W.1, and a strong board assembled under the chairmanship of Earl Grey. Among the directors are the Vice-Chairman, Sir G. B. Hunter (Chairman of Messrs. Swan, Hunter & Co.), the Duke of Northumberland, Commdr. R. W. Day, Major G. P. Denton, Sir Maxwell Hicks, Messrs. J. W. Beaumont Pease, Noel E. Peck, T. E. Thirlaway, and Edmund Hill (General Secretary of the Federation of British Industries). The venture is likely to be of the greatest possible benefit to the export trade of the British Empire, and is bound to make a strong appeal to our merchants and manufaturers. This British Trade Ship will be specially constructed for the purposes of an exhibition, and every detail of her equipment, from the engines to the fittings and furniture, will itself be an exhibit of British workmanship at its best. She will be as large as a first-class liner, having a gross tonnage of 20,000 tons, and in her internal arrangements will differ from any ship that has ever been floated. The scheme of the Trade Ship

is a great advance on the old-time bagman proceeding from town to town, and packing and re-packing his meagre samples at each halting place. A comparison between the two methods will reveal an enormous saving of time and cost. The arrival at each trade centre of the great white ship *British Industry* will be an event long looked forward to. At each port Reception Committees will have been formed in advance, whose duties it will be to make known the advent of the sea-borne Exhibition, to prepare lists of important firms and individuals, the description of the business in which they are interested, and all other information which may be useful. Fuller details concerning the Floating Exhibition are, we understand, to be available at the Shipbuilding, Engineering, and Machinery Exhibition at Olympia, which opened on September 7.

FOREIGN EXHIBITORS AT THE UTRECHT FAIR.—Great Britain—as may be seen from the figures quoted below—stands high in point of numbers in the list of foreign nations exhibiting at the Utrecht Fair, being placed second only to Germany, and having more than twice as many exhibitors as France. A few more applications for space have been received since these figures were compiled, so that the final numbers will be slightly greater, but the relative proportion between the different countries will probably remain as it is. It will be seen that there are rather more than half as many foreign as Dutch stall-holders.

	Direct Exhibitors.	Exhibiting through Dutch Agents.
Germany	92	64
England	47	30
Belgium	31	12
France	21	10
Switzerland	8	13
America	4	11
Czecho-Slovakia ...	7	3
Italy	4	3
Austria	4	2
Sweden	2	1
Finland	2	0
E. Africa	1	0
	223	140
Total Foreign Exhibitors		372
Total Dutch Exhibitors		706
Grand Total		1078

Two or three adverse factors have been encountered in securing the participation of the various European countries. The rate of exchange ruling with Holland makes exhibiting costs extremely high even for Belgium and France; while Austria, Italy, &c., are still more severely handicapped. An Austrian firm, for instance, has to pay 100,000 kronen for a space which costs a Dutch firm only 500 florins, and an English firm £45. The value of the £ sterling in Holland has changed so little that the price consideration is not such a serious one for the British exhibitor. The coal strike and the consequent disorganisation of business made it, however, absolutely impossible for many firms to participate who would otherwise have done so. The success or failure of the exhibition is naturally dependent upon the results obtained. So far as exhibits go, the Fair products which should prove extremely attractive to the buyer who wishes to make a comprehensive and comparative survey of what post-war Europe is making.

TREATMENT OF PHOSPHATES BY CALCINATION WITH A VIEW TO THEIR EMPLOYMENT AS PHOSPHATIC FERTILISERS.—(1) Process (Wolter Phosphate).—At least 1200° C. 100 parts of phosphorite, 70 of acid soda sulphate, 20 of calcium carbonate; 22 of sand, and 6 to 7 of carbon are melted. The product when cooled is broken up, dessicated and pulverised. (2) Process (D.R.P. 240875).—Crude phosphate is melted at 2000° C. until a test piece when cooled, pulverised, and treated with diluted SO_4H_2 coagulates albumen. (3) Process (D.R.P. 274409) (Phosphate Rhenania).—Phosphorites reduced to fragments are mixed with silico-potassic rocks, heated in special furnaces, without attaining melting point, until all hardens. (4) Process—Phosphatic substances are melted with a certain amount of lime and silica so as to obtain the combination $5CaO.P_2O_5SiO_2$. (5) Process.—Crude phosphates are heated with $CaCl_2$ or $MgCl_2$. The HCl liberated solubilises the phosphate. (6) Process (D.R.P. 258790).—Crude phosphate is melted with artificial silicates. The fused mass obtained is pulverised by aid of a current of steam. (7) Process.—Tetraphosphate (Italian invention) is obtained by calcination of finely pulverised phosphates with which 6 per cent alkalino-terreous carbonate is mixed. (8) Process.—The phosphoric acid of natural phosphates is made soluble in citrate by moderate heating with carbon, lime, wood, or petroleum. (9) Process (D.R.P. 715587).—Mixtures of phosphates of alumina are calcined at a temperature of at least 1150° C. with magnesia, in such proportion that a molecule of P_2O_5 will correspond to four molecules of MgO.—*Chimie et Industrie*, July, 1921.

SYNTHETIC ACETIC ACID.—The manufacture of acetic acid from acetylene, first accomplished by Berthelot, was yet in its infancy in 1914, but the effect of the war was to bring it within the field of industrial work. A history of this question and an account of the various difficulties encountered in the employment of scientific methods are given by M. Deschiens in *Chimie et Industrie* of March, April, and May. In conclusion, after mentioning the maximum normal productions of some synthetic acetic acid works, comparatively with those of acetic acid and lime acetate from pyroligneous systems, utilised in France and the United States, M. Deschiens remarks that the cost price of synthetic acid being now less, competition may be expected. However, some new applications are likely to absorb a production which will continue to increase, such as those in the cellulose acetate industry; synthetic indigo, and manufacture of various pharmaceutic products. In spite of this increase, competition, no doubt, will come into play. In his report on carbonising wood, M. Deschiens remarks that synthetic acetic acid, almost unlimited in production, will find its utilisation subordinate to cost-price. It seems probable that new works for manufacture of a more or less great quantity of synthetic acetic acid will themselves utilise it and put acetic by-products in the markets, a procedure which cannot fail to result

NEW COMPANIES.

The under-mentioned particulars of New Companies recently registered are taken from the Daily Register compiled by Jordan & Sons, Limited, Company Registration Agents, Chancery Lane, W.C.2.

Courtin and Warner, Limited.—(176508)—Registered August 29th, 1921. 8, Harp Lane, E.C. To carry on the business of Manufacturing Chemists. Nominal Capital: £20,000 in 20,000 Ordinary Shares of £1 each. Directors: H. G. Warner, 28, Homefield Road, Wimbledon Common, S.W.; L. E. Courtin, Sill Lodge, Stonebridge Park, N.W.10. Qualification of Directors: 50 Shares.

Burns (Westhoughton), Limited.—(176505)—Registered August 29th, 1921. Railway Works, Slack Lane, Westhoughton, Lancashire. To carry on the business of Wholesale and Retail and Manufacturing Chemists. Nominal Capital: £3,000 in 3,000 Shares of £1 each. Directors: Catherine Holt, 192, Chorley New Road, Bolton; J. Lythgoe, 31, Park Avenue, Sharples Park, Bolton; E. Cutsforth, 69, Swan Lane, Bolton. Qualification of Directors: £100. Remuneration of Directors: 50% of the net half-yearly profits.

G. Clarkson, Limited.—(176498)—Registered August 27th, 1921. 26, Wortley Lane, Leeds. To acquire and carry on the business of Pharmacy and Drug Store Proprietors. Nominal Capital: £200 in 200 Shares of £1 each. Directors: G. Clarkson, 10, Alcester Road, Leeds; Florence Clarkson, 10, Alcester Road, Leeds; F. Lockwood, 25, Station Road, Golcar, Near Huddersfield. Qualification of Directors: 1 Share. Remuneration of Directors: To be voted by Company.

Rainbow Dyes, Limited.—(176517)—Registered August 29th, 1921. To carry on the business of Dyers. Nominal Capital: £2,100 in 1,900 Shares of £1 each and 2,000 Shares of 1/- each. Directors: To be appointed by Subscribers. Remuneration of Directors: To be voted by Company in General Meeting. Subscribers: J. E. Stevens, 27, Trigon Road, Clapham, S.W.; R. Martin, Hawthorn Cottage, York Square, Stepney, E.14.

A. E. Ashby, Limited.—(176523)—Registered August 30th, 1921. 105, Woodhouse Street, Leeds. To carry on the business of Chemists and Druggists. Nominal Capital: £500 in 500 Shares of £1 each. Directors: A. E. Ashby, 105, Woodhouse Street, Leeds; Alice Ashby, 105, Woodhouse Street, Leeds. Qualification of Directors: 1 Share. Remuneration of Directors: To be voted by Company in General Meeting.

New Patents.

This List is specially compiled for the *Chemical News* by Messrs. Rayner & Co., Registered Patent Agents, of 5, Chancery Lane, London, W.C.2., from whom all information relating to Patents, Trade Marks and Designs can be obtained gratuitously.

Latest Patent Applications.

22436—Davies, J.—Laying of magnesium cements on metallic surfaces. August 24.
22381—General Electric Co., Ltd.—Manufacture of tungsten. August 23.
22645—Hansford, J. B.—Manufacture of neutral sulphate of ammonia. August 26.
22270—Hoover Co.—Process of recovering aluminium chloride from spent or partly-spent catalyzing agent. August 22.
22281—Macullam, A. D.—Derivatives of nitrophenylstibinic acid, and process of preparing same. August 22.
22393—Soc. l'Air Liquide Soc. Anon. pour l'Etude et l'Exploitation des procedes, G. Claude.—Synthesis of ammonia. August 23.

Specification published this Week.

167941—British Cellulose and Chemical Manufacturing Co., Ltd., Bader, W. and Nightingale, D. A.—Manufacture of alkylamides aromatic sulphonic acids.

Messrs. Rayner & Co., will obtain printed copies of the published specifications and will forward on post free for the official price of 1/- each.

PATENTS, TRADE MARKS. Handbook and advice free—B. T. King, British and U. S. Regd. Patent Attorney, 146a, Queen Victoria St., London. 35 years reference.

NOTICES.

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CHEMICAL ENGINEERING. Lectures. 1st year, Friday, 7.15 to 8.15. Lectures. 2nd year, Friday, 8.30 to 9.30 Laboratory. Wednesday, 7 to 9.30. H. Griffiths, B.Sc., A.R.C.S.
BACTERIOLOGY. Tuesday, Wednesday and Friday, 7 to 9.30. J. H. Johnston, M.Sc., F.I.C.
ANALYSIS OF FOODS. Wednesday, 7 to 9.30. J. H. Johnston, M.Sc., F.I.C.
TESTING OF DISINFECTANTS. Tuesday, 7 to 9.30. J. H. Johnston, M.Sc., F.I.C.
ENZYME CHEMISTRY. Monday, 6.30 to 9.30. S. S. Zilva, Ph. D.
FLOUR MILLING. A. 1st Year Course. (1) Flour Milling. Thursday, 7 to 8.30. G. E. Smith. (2) Elementary Science as applied to Flour Milling. Thursday, 6 to 7. A. Houssa, B.Sc., A.I.C. (3) Machine Drawing, Friday, 7.30 to 9.30.
B. 2nd Year Course. (1) Flour Milling. Wednesday, 7 to 8.30. G. E. Smith. (2) Elementary Science as applied to Flour Milling. Wednesday, 6 to 7. A. Houssa, B.Sc., A.I.C. (3) Machine Drawing. Friday, 7.30 to 9.30.
OILS AND FATS. (About 28 Lectures). Tuesday, 7.15 to 9.45. W. H. Simmons, B.Sc., F.I.C.
LUBRICATING OILS AND GREASES. Friday, 7.15 to 9.45. W. H. Simmons, B.Sc., F.I.C.
PAPER MAKING. Monday, 7.15 to 9.45. (1st term). R. Marx, B.Sc.
PAPER TESTING. 1st year, Friday, 7.15 to 9.45. 2nd year, Wednesday, 7 to 9.30. D. R. Davey.
THE TECHNOLOGY OF FUELS. Friday, 7 to 9.30. (Commencing October 14th). A. R. Pearson, M.Sc.
ATOMIC WEIGHTS AND ISOTOPES. (4 Weekly Lectures). Wednesday, 5.45 to 6.45. (Commencing October 12th). Dr. F. W. Aston, F.R.S.
Day Courses commence Tuesday, September 27th.
Evening Courses commence Monday, September 26th.
Enrolment of Evening Students commences Tuesday, September 20th.
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THE CHEMICAL NEWS.
VOL. CXXIII., No. 3206.

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

EDINBURGH, 1921.

THE LABORATORY OF THE LIVING ORGANISM.

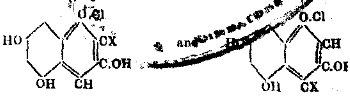
ADDRESS DELIVERED BEFORE SECTION B (CHEMISTRY)

BY M. O. FORSTER, D.Sc., F.R.S., President of the Section.

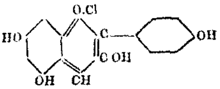
(Concluded from p. 152).

THE earliest of these papers, published in conjunction with A. E. Everest, dealt with cornflower pigments, and indicated that the distinct shades of colour presented by different parts of the flower are caused by various derivatives of one substance; thus the blue form is the potassium derivative of a violet compound which is convertible into the red form by oxonium salt-formation with a mineral or plant acid. Moreover, as found in blossoms, the chromogen was observed to be combined with two molecular proportions of glucose and was isolated as crystalline cyanin chloride; hydrolysis removed the sugar and gave cyanidin chloride, also crystalline. Applying these methods more generally, Willstätter and his other collaborators have examined the chromogens which decorate the petals of rose, larkspur, hollyhock, geranium, salvia, chrysanthemum, gladiolus, ribes, tulip, zinnia, pansy, petunia, poppy, and aster, whilst the fruitskins of whortleberry, bilberry, cranberry, and cherry, plum grape, and sloe, have also been made to yield the pigment to which there characteristic appearance is due.

The type of structural formula by which the anthocyanidins are now represented was proposed in 1914, simultaneously and independently by Willstätter and by Everest; incidentally their separate memoirs afford an unusual example of synchronous publication, each having been communicated to the respective academies on the same day, March 26. Willstätter identified phloroglucinol (1:3 : 5-trihydroxybenzene) as a common product of hydrolysing anthocyanidins with alkali, obtaining also *p*-hydroxybenzoic acid from pelargonidin, protocatechuic (3 : 4-dihydroxybenzoic) acid from cyanidin, and gallic (3 : 4 : 5-trihydroxybenzoic) acid from delphinidin. According two alternative formulæ



in which X represents the substituted benzene ring which appears in the form of a phenolcarboxylic acid on hydrolysis. Later in the same year he confirmed (with Mallison) the former of these representations by reducing quercitin to cyanidin chloride (see Fig. 5) and (with Zechmeister) by effecting a complete synthesis of pelargonidin chloride



from 2 : 4 : 6-trihydroxybenzaldehyde.

Everest reached the same conclusion by recognising the significance of the fact that a flavone, *e.g.*, luteolin, and a flavonol, *e.g.*, morin, yield red pigments on reduction; he therefore reduced quercitrin (the rhamnoside of quercitin) to cyanidin, and rutin (the rhamnoglucoside of quercitin, and identical with osyritin, myrticolorin, and violaquercitrin) to cyanin. Moreover, he showed that the petals of many yellow flowers, *e.g.*, daffodil, wallflower, tulip, crocus, jasmin, primrose, and viola, or the white blossoms of narcissus, primula, and tulip all yield red pigments on careful reduction, and in subsequent papers (*e.g.*, with A. J. Hall, 1921) has indicated reduction of yellow sap-pigments belonging to the flavonol group as representing the probable course of anthocyan-formation in plants. In this connection it is noteworthy that an association between the pigments of sap and of blossoms was adumbrated in 1855 by Martens, who suggested that a faintly yellow substance in plant sap, when oxidised in presence of alkalis and light, produces the yellow pigments, and that these, by further oxidation, change into the red colouring-matters. Everest has shown that reduction is the process actually involved and that flavonols are the precursors of anthocyans, not *vice versa* as suggested by other investigators; moreover, he found (1918) that "Black Knight" petals contain a glucoside of delphinidin, whilst the corresponding flavonol, myricetin, is present in the sap, also as a glucoside (see Fig. 6).

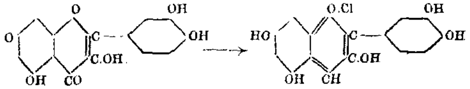
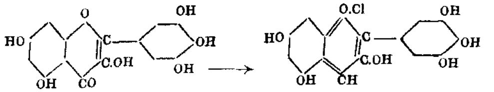


FIG. 5.

Hence it will be seen that pelargonidin, cyanidin, delphinidin, corresponding to the three above-mentioned phenolcarboxylic acids, are the fundamental materials in the group of anthocyan pig-

flavonols, kaempferol, quercitin, and myricetin respectively. The variations upon these types which present themselves in blossoms are twofold, due to (1) the number and position of entrant methyl groups, and (2) the number and character of the aldose molecules which go to form their glucosides. Belonging to the first group are peonidin (monomethylated cyanidin), ampelopsidin, myrtillidin, and petunidin (monomethylated delphinidin) with malvidin and oenidin (dimethylated delphinidin). The second group arise from combination with glucose, galactose, or rhamnose, the greatest proportion of pigments occurring as mono- or diglucosides. Thus callistephin and salvinin are the mono- and diglucoside of pelargonidin; asterin and chrysanthemin are monoglucosides and idaein a galactoside of cyanidin, derived from which are the diglucosides cyanin and mekocyanin, and the rhamnoglucoside, keracyanin; violanin is a rhamnoglucoside of delphinidin, whilst delphinin, when hydrolysed with hydrochloric acid, yields delphinidin chloride, glucose, and *p*-hydroxybenzoic acid in the molecular proportion, 1 : 2.

Thus may the chemist find fresh delight in the hedgerow and the garden by reflecting on the processes which lead to the molecular structures lying well within his mental horizon, and adorning those familiar models with all the chromatic splendours of snapdragon, pansy, rose, and larkspur. The gustatory and æsthetic thrill engendered in consuming summer pudding and custard is heightened by the soothing blend of egg-yolk lutein and the crimson contributed to the colour scheme by the raspberry and currant anthocyanins.



Myricetin. Delphinidin Chloride.

FIG. 6.

Micro-Biochemistry.

Amongst the many sources of pleasure to be found in contemplating the wonders of the universe, and denied to those untrained in scientific principles, is an appreciation of infra-minute quantities of matter. It may be urged by some that within the limits of vision imposed by telescope and microscope, ample material exists to satisfy the curiosity of all reasonable people, but the appetite of scientific inquiry is insatiable, and chemistry alone, organic, inorganic, and physical, offers an instrument by which the investigation of basal changes may be carried to regions beyond those encompassed by the astronomer and the microscopist.

It is not within the purpose of this address to survey that revolution which is now taking place in the conception of atomic structure; contributions to this question will be made in our later proceedings and will be followed with deep interest by all members of the Section. Fortunately for our mental balance, the discoveries of the current century, whilst profoundly modifying the atomic imagery inherited from our predecessors, have not yet seriously disturbed the ...

emphasise in a forcible manner the intimate connection between different branches of science, because it is from the mathematical physicist that these new ideas have sprung. Their immediate value is to reaffirm the outstanding importance of borderline research and to stimulate interest in submicroscopic matter.

This interest presents itself to the chemist very early in life and dominates his operations with such insistence as to become axiomatic. So much so that he regards the universe as a vast theatre in which atomic and molecular units assemble and interplay, the resulting patterns into which they fall depending on the physical conditions imposed by nature. This enables him to regard micro-organisms as co-practitioners of his craft, and the chemical achievements of these humble agents have continued to excite his admiration since they were revealed by Pasteur. The sixty years which have now elapsed are rich in contributions to that knowledge which comprises the science of micro-biochemistry, and in this province, as in so many others, we have to deplore the fact that the principal advances have been made in countries other than our own. On this ground, fortified by the intimate relation of the science to a number of important industries, A. Chaston Chapman, in a series of illuminating and attractive Cantor Lectures in December, 1920, iterated his plea of the previous year for the foundation of a National Institute of Industrial Micro-biology, whilst H. E. Armstrong, in Birmingham a few weeks later, addressed an appeal to the brewing industry, which, although taking the form of a memorial lecture, is endowed with many lively features depicting in characteristic form the manner in which the problems of brewing chemistry should, in his opinion, be attacked.

Lamenting as we now do so bitterly the accompaniments and consequences of war, it is but natural to snatch at the slender compensations which it offers, and not the least among these must be recognised the stimulus which it gives to scientific inquiry. Pasteurs *Etudes sur la Bière* were inspired by the misfortunes which overtook his country in 1870-71, and the now well-known process of Connstein and Lüdecke for augmenting the production of glycerol from glucose was engendered by parallel circumstances. That acquaintance with the yeast-cell which was an outcome of the former event had, by the time of the latter discovery, ripened into a firm friendship, and those who slander the chemical activities of this genial fungus are defaming a potential benefactor. Equally culpable are those who ignore them. If children were encouraged to cherish the same intelligent sympathy with yeast-cells which they so willingly display towards domestic animals and silkworms, perhaps there would be fewer crazy dervishes to deny us the moderate use ...

problems by habitual excess.

Exactly how the cell accomplishes its great adventure remains a puzzle, but many parts of the machinery have already been recognised. Proceeding from the discovery of zymase (1897), with passing reference to the support thus given by Buchner to Liebig's view of fermentation, Chapman emphasises the importance of contributions to the subject by Harden and W. J. Young, first revealing the dual nature of zymase and the distinctive properties of its co-enzyme (1904), next in recognising the acceleration and total increase in fermentation produced by phosphates, consequent on the formation of a hexose-diphosphate (1908):

$$2C_6H_{12}O_6+2Na_2HPO_4= 2CO_2+2C_2H_6O+C_6H_{10}O_4(PO_4Na_2)_2+2H_2O.$$

In this connection it will be remembered that a pentose-phosphate is common to the four nucleotides from which yeast nucleic acid is elaborated. The stimulating effect developed by phosphates would not be operative if the cell were not provided with an instrument for hydrolysing the hexose-diphosphate as produced, and this is believed by Harden to be supplied in the form of an enzyme, hexosephosphatase, the operation of which completes a cycle. As to the stages of disruption which precede the appearance of alcohol and carbon dioxide, that marked by pyruvic acid is the one which is now most favoured. The transformation of pyruvic acid into acetaldehyde and carbon dioxide under the influence of a carboxylase, followed by the hydrogenation of aldehyde to alcohol, is a more acceptable course than any alternative based upon lactic acid. Moreover, Fernbach and Schoen (1920) have confirmed their previous demonstration (1914) of pyruvic acid formation by yeast during alcoholic fermentation.

The strict definition of chemical tasks allotted to yeasts, moulds, and bacteria suggests an elaborate system of microbial trades-unionism. E. C. Grey (1918) found that *Bacillus coli communis* will, in presence of calcium carbonate, completely ferment forty times its own weight of glucose in forty-eight hours, and later (1920) exhibited the threefold character of the changes involved which produce (1) lactic acid, (2) alcohol with acetic and succinic acids, (3) formic acid, carbon dioxide, and hydrogen. Still more recent extension of this inquiry by Grey and E. G. Young (1921) has shown that the course of such changes will depend on the previous experience of the microbe. When its immediate past history is anærobic, fermentation under anærobic conditions yields very little or no lactic acid, and greatly diminishes the production of succinic acid, whilst acetic acid appears in its place; admission of oxygen during fermentation increases the formation of lactic, acetic, and succinic acids, diminishes the formation of hydrogen, carbon dioxide, and formic acid, but leaves the quantity of alcohol unchanged. The well-known oxidising effect of *Aspergillus niger* has been shown by J. N. Currie (1917) to proceed in three stages marked by citric acid, oxalic acid, and carbon dioxide, whilst Wehmer (1918) has described the conditions under which citric acid and, pricpally, fumaric acid are produced by *Aspergillus fumaricus*, a mould also requiring oxygen for its purpose. The lactic bacteria are a numerous family and resemble those producing acetic acid in their venerable record of service to mankind, whilst among the most interesting of the parvenus are those responsible for the conversion of starch into butyl alcohol and acetone. Although preceded by Schardinger (1905), who discovered the ability of *B. macerans* to produce acetone with acetic and formic acids, but does not appear to have pursued the matter further, the process associated with the name of A. Fernbach, and the various modifications which have been introduced during the past ten years are those best known in this country, primarily because of the anticipated connection with synthetic rubber, and latterly on account of the acetone famine arising from the War. The King's Lynn factory was resuscitated and arrangements had just been completed for adapting spirit distilleries to application of the process when, owing to the shortage of raw material in 1916, operations were transferred to Canada, and ultimately attained great success in the factory of British Acetones, Toronto.

Much illuminating material is to he found in the literature of 1919-20 dealing with this question in its technological and bacteriological aspects. Ingenuity has been displayed in attempting to explain the chemical mechanism of the process, the net result of which is to produce roughly twice as much butyl alcohol as acetone. The fermentation itself is preceded by saccharification of the starch, and in this respect the bacteria resemble those moulds which have lately been brought into the technical operation of starch-conversion, especially in France. The amyloclastic property of certain moulds has been known from very early times, but its application to spirit manufacture is of recent growth and underlies the amylo-process which substitutes *Mucor Boulard* for malt in effecting saccharification. Further improvement on this procedure is claimed for *B. mesentericus* which acts with great rapidity on grain which has been soaked in dilute alkali; it has the advantage of inferior proteolytic effect, thus diminishing the waste of nitrogenous matter in he raw material.

Reviewing all these circumstances we find that, just as the ranks of trades-union labour comprise every kind of handicraftsman, the practitioners of micro-biochemistry are divisible into producers of hydrogen, carbon dioxide, formic acid, acetaldehyde, ethyl alcohol, acetic, oxalic, and fumaric acids, acetone, dihydroxyacetone, glycerol pyruvic, lactic, succinic and citric acids, butyl alcohol, butyric acid. Exhibiting somewhat greater elasticity in respect of overlapping tasks, they nevertheless go on strike if underfed or dissatisfied with their conditons;; on the other hand, with sufficient nourishment and an agreeable temperature, these micro-trades-unionists display the unusual merit of working for 24 hours a day. One thing, however, they have consistently refused to do. Following his comparison of natural and synthetic monosaccharides towards different families of yeast (1894), Fischer and others have attempted to beguile unsuspecting microbes into acceptance of molecules which do not harmonise with their own enzymic asymmetry. Various *apéritifs* have been administered by skilled *chefs de cuisine*, but hitherto the little fellows have remained obdurate.

Photosynthesis.

Beyond a placid acceptance of the more obvious benefits of sunshine, the great majority of educated people have no real conception of the sun's contribution to their existence. What proportion of those who daily use the metropolitan system of tube-railways, for instance, could trace the connection between their progress and the sun? Very moderate instruction comprising the elements of chemistry and energy would enable most of us to apprehend this modern wonder, contemplation of which might help to alleviate the distresses and exasperation of the crush-hours.

For many years past, the problem connected with solar influence which has most intrigued the chemist is to unfold the mechanism enabling green plants to assimilate nitrogen and carbon. Although atmospheric nitrogen has long been recognised as the ultimate supply of that element from which phyto-protoplasm is constructed, modern investigation has indicated as necessary a stage involving association of combined nitrogen with the soil prior to absorption of nitrogen compounds by the roots, with or without bacterial co-operation. Concurrently, the agency by which green plants assimilate carbon is believed to be chlorophyll, operating under solar influence by some such mechanism as has been indicated in a preceding section.

Somewhat revolutionary views on these two points have lately been expressed by Benjamin Moore, and require the strictest examination, not merely owing to the fundamental importance of an accurate solution being reached, but also on account of the stimulating and engaging manner in which he presents the problem. Unusual psychological features have been introduced. Moore's "Biochemistry," published three months ago, will be read attentively by many chemists, but the clarity of presentation and the happy sense of conviction which pervade its pages must not be allowed to deter independent inquirers from confirming or modifying his conclusions. The book assumes a novel biochemical aspect by describing the life-history of a research. The first two chapters, written before the experiments were begun, suggest the conditions in which the birth of life may have occurred, whilst their successors describe experiments which were conducted as a test of the speculations and are already receiving critical attention from others (*e.g.*, Baly, Heilbron and Barker, *Transactions of the Chemical Society*, 1921, p. 1025).

It is with these experiments that we are, at the moment, most concerned. The earliest were directed towards the synthesis of simple organic materials by a transformation of light energy under the influence of inorganic colloids, and indicated that formaldehyde is produced when carbon dioxide passes into uranium or ferric hydroxide sols exposed to sunlight or the mercury arc lamp. Moore then declares that, although since the days of de Saussure (1804) chlorophyll has been regarded as the fundamental agent in the photosynthesis of living matter, there is no experimental evidence that the primary agent may not be contained in the colourless part of the chloroplast, chlorophyll thus being the result of a later synthetic stage. "The function of the chlorophyll may be a protective one to the chloroplast when exposed to light, it may be a light screen as has been suggested by Pringsheim, or it may be concerned in condensations and polymerisations subsequent to the first act of synthesis with production of formaldehyde" (p. 55). In this connection it is significant that chlorosis of green plants will follow a deficiency of iron even in presence of sunlight (Molisch, 1892), and that development of chlorophyll can be restored by supplying this deficiency, although iron is not a component of the chlorophyll molecule; moreover, green leaves etiolated by darkness and then exposed to light regain their chlorophyll, which is therefore itself a product arising from photosynthesis.

H. Thiele (1907) recorded the swift conversion of nitrate into nitrite by the rays from a mercury quartz lamp, whilst O. Baudisch (1910) observed that daylight effects the same change, and from allied observations was led (1911) to conclude that assimilation of nitrate and nitrite by green plants is a photochemical process. Moore found (1918) that in solutions of nitrate undergoing this reduction green leaves check the accumulation of nitrite, indicating their capacity to absorb the more active compound. Proceeding from the hypothesis that one of the organisms arising earliest in the course of evolution must have possessed, united in a single cell, the dual function of assimilating both carbon and nitrogen, he inquired (1918) whether the simplest unicellular algæ may not also have this power. He satisfied himself that in absence of all sources of nitrogen excepting atmospheric, and in presence of carbon dioxide, the unicellular algæ can fix nitrogen, grow and form proteins by transformation of light energy; the rate of growth is accelerated by the presence of nitrites or oxides of nitrogen, the latter being supplied in gaseous form by the atmosphere. From experiments (1919) with green seaweed (*Enteromorpha compressus*), Moore concluded also that marine algæ assimilate carbon *from the bicarbonates of calcium and magnesium* present in sea-water, which thereby increases in alkalinity, and further convinced himself that the only source of nitrogen available to such growth is the atmosphere. A description of these experiments, which were carried out in conjunction with E. Whitley and T. A. Webster, has appeared also in the *Proceeding of the Royal Society*, 1920 and 1921.

For the purpose of distinguishing between (1) the obsolete view of a vital force disconnected with such forms of energy as are exhibited by non-living transformers and (2) the existence in living cells of only such energy forms as are encountered in non-living systems, Moore uses the expression "biotic energy" to represent that form of energy peculiar to living matter. "The conception, in brief, is that biotic energy is just as closely, and no more, related to the various forms of energy existing apart from life, as these are to one another, and that in presence of the proper and adapted energy transformer, the living cell, it is capable of being formed from or converted into various of these other forms of energy, the law of conservation of energy being obeyed in the process just as it would be if an exchange were taking place between any two or more of the inorganic forms" (p. 128). The most characteristic feature of biotic energy, distinguishing it from all other forms, is the power which it confers upon the specialised transformer to proliferate.

Conclusion.

In "The Salvaging of Civilisation," H. G. Wells has lately directed the attention of thoughtful people to the imperative need of reconstructing our outlook on life. Convinced that the state-motive which, throughout history, has intensified the self-motive must be replaced by a world-motive if the whole fabric of civilisation is not to crumble in ruins, he endeavours to substitute for a League of Nations the conception of a World State. In the judgment of many quite benevolent critics his essay in abstract thought lacks practical value because it underestimates the combative selfishness of individuals. Try to disguise it as one may, this quality is the one which has enabled man to emerge from savagery, to build up that most wonderful system of colonial organisation, the Roman Empire, and to shake off the barbaric lethargy which engulfed Europe in the centuries following the fall of Rome. The real problem is how to harness this combative selfishness. To eradicate it seems impossible, and it has never been difficult to find glaring examples of its insistence among the apostles of eradication. Why cry for the moon? Is it not wiser to recognise this quality as an inherent human characteristic, and whether we brand it as a vice or applaud it as a virtue endeavour to bend it to the elevation of mankind? For it could so be bent. Nature ignored or misunderstood is the enemy of man: nature studied and controlled is his friend. If the attacking force of this combative selfishness could be directed, not towards the perpetuation of quarrels between different races of mankind, but against nature, a limitless field for patience, industry, ingenuity, imagination, scholarship, aggressiveness, rivalry, and acquisitiveness would present itself; a field in which the disappointment of baffled effort would not need to seek revenge in the destruction of our fellow-creatures; a field in which the profit from successful enterprise would automatically spread through all the communities. Surely it is the nature-motive, as distinct from the state-motive or the world-motive, which alone can salvage civilisation.

Before long, as history counts time, dire necessity will have impelled mankind to some such course. Already the straws are giving their proverbial indication. The demand for wheat by increasing populations, the rapidly diminishing supplies of timber, the wasteful ravages of insect pests, the less obvious, but more insidious depredations of our microscopic enemies, and the blood-curdling fact that a day must dawn when the last ton of coal and the last gallon of oil have been consumed, are all circumstances which, at present recognised by a small number of individuals comprising the scientific community, must inevitably thrust themselves upon mankind collectively. In the campaign which will then follow, chemistry must occupy a prominent place because it is this branch of science which deals with matter more intimately than any other, revealing its properties, its tranformations, its application to existing needs, and its response to new demands. Yet the majority of our people are denied the elements of chemistry in their training, and thus grow to manhood without the slightest real understanding of their bodily processes and composition, of the wizardry by which living things contribute to their nourishment and to their æsthetic enjoyment of life.

It should not be impossible to bring into the general scheme of secondary education a sufficiency of chemical, physical, mechanical, and biological principles to render every boy and girl of sixteen possessing average intelligence at least accessible by an explanation of modern discoveries. One fallacy of the present system is to assume that relative proficiency in the inorganic branch must be attained before approaching organic chemistry. From the standpoint of correlating scholastic knowledge with the common experiences and contacts of daily life this is quite illogical, from baby's milk to grandpapa's Glaxo the most important things are organic, excepting water. Food (meat, carbohydrate, fat), clothes (cotton, silk, linen, wool), and shelter (wood) are organic, and the symbols for carbon, hydrogen, oxygen, and nitrogen can be made the basis of skeleton representations of many fundamental things which happen to us in our daily lives without first explaining their position in the periodic table of all the elements. The curse of mankind is not labour, but waste; misdirection of time, of material, of opportunity, of humanity.

Realisation of such an ideal would people the ordered communities with a public alive to the verities, as distinct from irrevelancies of life, and apprehensive of the ultimate danger with which civilisation is threatened. It would inoculate that public with a germ of the nature-motive, producing a condition which would reflect itself ultimately upon those entrusted with government. It would provide the mental and sympathetic background upon which the future truthseeker must work, long before he is implored by a terrified and despairing people to provide them with food and energy. Finally, it would give an unsuspected meaning and an unimagined grace to a hundred commonplace experiences. The quivering glint of massed bluebells in broken sunshine, the joyous radiance of young beech leaves against the stately cedar, the perfume of hawthorn in the twilight, the florid majesty of rhododendron, the fragrant simplicity of lilac, periodically gladden most careless heart and the least reverent spirit; but to the chemist they breathe an added message, the assurance that a new season of refreshment has dawned upon the world, and that those delicate syntheses, into the mystery of which it is his happy privilege to penetrate, once again are working their inimitable miracles in the laboratory of the living organism.

THE TIME INTERVAL BETWEEN THE ABSORPTION AND EMISSION OF LIGHT IN CASES OF FLUORESCENCE.*

By PROF. R. W. WOOD, For.Mem.R.S.

IN the case of mercury vapour, illuminated by the instantaneous flash of an aluminium spark, it has been found that the vapour remains non-luminous during the period of excitation and for about 1/15000 sec. after, subsequently bursting out in a flash of green fluorescent light. This appears to

*Read before the British Association, Edinburgh Meeting (Section A).

be the first observation of a fluorescent or phosphorescent body remaining dark during the period of illumination. Other substances have been observed with a new type of phosphoroscope which records the phenomena of phosphorescence to 1/400000 sec. Nothing analogous in its behaviour to mercury vapour has been found up to the present time, however.

It is only freshly formed mercury vapour which exhibits the phenomenon of fluorescence. No trace of visible luminescence is shown by mercury vapour at any density, or by any light stimulation, *unless metallic mercury is present* and liberating nascent molecules. It is believed that these are diatomic when they first leave the metal, subsequently breaking up into monatomic molecules.

APRICOT KERNEL OIL AND ITS CONGENERS.

Possible Substitutes for Almond Oil.

By CHAS. F. JURITZ, M.A., D.Sc.,
Agricultural Research Chemist.

Some years ago a correspondent of *The Chemist and Druggist* complained of the confusion caused by the similarity of names assigned by the British Pharmacopœia and its adjuncts to the various oils derived from the almond, the apricot, and the peach. These names include:—

1. *Oleum amygdalae* or *Oleum amygdalae dulcis*: Almond oil, or oil of sweet almonds.
2. *Oleum amygdalae amarae essentiale*: Essential oil of bitter almonds.
3. *Oleum amygdalae persicae*: Peach kernel (or apricot kernel) oil.
4. *Oleum amygdalae persicae essentiale*: Essential oil of peach (or apricot) kernels.

Nos. 1 and 3 of the above are very similar to each other in character and constitution. They are both fixed oils: that is to say, they are not capable of being distilled but decompose on the continued application of heat. They pre-exist as fixed oils in the seeds of the almonds, the peach, and the apricot.

Nos. 2 and 4 also bear considerable resemblance to one another, but differ greatly from Nos. 1 and 3. They are both volatile essential oils, distilling readily at a conveniently low temperature. They do not occur naturally in apricot, peach, or almond kernels, but are formed only when these kernels are subjected to special treatment.

A short explanation may suffice to make the latter statement more clear. The kernels of the apricot and the peach, as well as *bitter* almonds, contain a nitrogenous bitter principle, or glucoside, called amygdalin. When acted on in a certain way by dilute acids or by natural ferments, this bitter principle is broken up, and the volatile oil above spoken of is formed. Now it so happens that apricot and peach kernels, as well as almonds, *both bitter and sweet*, contain a ferment known as emulsin, which consists of two enzymes prunase and amygdalase. This ferment is capable of acting on amygdalin, producing what we know as the essential oil of bitter almonds, the amygdalin in the process taking up water and forming benzaldehyde and hydrocyanic acid.

It follows then that from the seeds above referred to we can obtain these two classes of oil, first obtaining the fixed oil by what is called cold expression, and then allowing the ferment to act freely on the oil-freed residue so as to produce the essential oil which is subsequently obtained by the process of distillation.

Passing over from the general to the particular we may now take a very brief glance at each of these oils in turn.

Almond Oil.—Almond oil (*Oleum amygdalae*), as above stated, is a fixed oil. It is one of the non-drying class, and belongs to the olive oil group. It consists, when pure, mainly of olein, together with a little linolein and palmitin, but is free from stearin. It is almost water-white in colour and almost tasteless in flavour. The odour, too, is barely perceptible. It is obtained by cold expression from either the sweet or the bitter almond. Sweet almonds yield from 40 per cent to 45 per cent of this oil, and bitter almonds from 35 per cent to 38 per cent. It is usually prepared from bitter almonds, which are a cheaper source, especially as the residual cake after expression of the fixed oil can be used for the preparation of the essential oil.

According to Lewkowitsch the fixed oil so obtained does not easily turn rancid, as Allen says it does. Lewkowitsch also states that "oil of sweet Almonds, French," is nothing else but apricot kernel oil, or a mixture of the latter witb peach kernel oil. These are so closely related to almond oil that distinction between the two is very closely related to almond oil that distinction between the two is very difficult. Almond oil is usually employed only in pharmacy, its high cost (4s. to 5s. per lb.) precluding its employment for other purposes. It has had, however, an extensive use medicinally as a demulcent, emollient, and laxative, serves well in cough-mixtures, and is said to be better adapted than olive oil for ointments and emulsions, producing a whiter ointment. It has, furthermore, found employment as a cosmetic and in soap manufacture. It is officially designated by the British Pharmacopœia as a constituent of certain liniments, oils, and ointments. The positon in South Africa, it is understood, is that even for pharmaceutical preparations true almond oil is seldom used (on account of its high price), except in cases where its employment is imperative. Accordingly pharmacists have been turning their attention to the substitution of other oils.

Peach Kernel Oil.—As already stated, apricot and peach kernel oils are very similar to almond oil in character, and can, in most cases, be substituted for the latter without detriment, and at less cost to the producer. They are obtained from apricot and peach kernels respectively by a process corresponding to that whereby almond oil is obtained from almonds. Peach kernels, thus treated, yield from 32 to 35 per cent of fixed oil, and its chief employment is as a substitute for almond oil. Bieber, in fact, asserted that most of the almond oil of commerce (*Oleum amygda-*

lae) is really only peach kernel oil (*Oleum amygdalae persicae*). Even the latter, however, is too high in price at 3s. per lb. to assure its general use, and hence, wherever possible, its place—in South Africa at least—has been taken mainly by pea-nut oil (*Oleum arachis*) for toilet articles and in other cases where the use of pea-nut or sesame oil is permissible. It may also be noted that the British Pharmacopœia expressly sanctions the substitution of arachis oil or sesame oil, *but no other oil or fat,* for olive oil, in India and in the eastern, African, and Australasian divisons of the Empire in making such preparations as camphorated oil, lead plaster, resin ointment, and other liniments, plasters, ointments, and soaps, in which the use of olive oil is directed.

Apricot Kernel Oil.—It is possible that, if the price allowed, apricot kernel oil would be preferred to pea-nut oil where the character of the oil employed is not subject to restrictions. The price of apricot kernel oil, however, is 3s. 9d. per lb., while pea-nut oil is obtainable at 1s. 7d. per lb., so that, for the presenr, this substitution is out of the question.

The oil may be obtained by crushing and grinding the entire seeds of the apricot—kernel and shell together—and then pressing for extraction of the oil. This extraction may be aided by the application of heat or the addition of water, or both.

About fifteen years ago, Messrs. Stafford Allen & Sons, of Finsbury, London, who claimed to have been the first to introduce British-pressed oil of peach or apricot kernels, stated that the apricot (*Prunus armeniaca*) rather than the peach (*Amygdalus persica*) had become the chief source of the oil, and they, thereforre, suggested that the confusion referred to at the commencement of the present article would be lessened by altering the name of peach (or apricot) kernel oil from *Oleum amygdalae persicae* to *Oleum pruni armeniacae.* Apricot kernels contain from 40 to 45 per cent of this fixed oil, which is used as an edible oil, in addition to replacing almond oil.

Some nine months ago it was observed that the Wellington Preserving Co. was advertising for sale large quantities of apricot stones. In order to ascertain the proportion of oil likely to be yielded by these stones and also the physical contents of such oil, and to compare these with recorded analyses of apricot kernel oil from elsewhere, a bag of these stones was very kindly supplied by the company at my request. The kernels were shelled and the oil, obtained both by cold expression at a pressure of two tons per square inch, and by ether extraction, was duly examined in this laboratory by Mr. W. J. Copenhagen.

Laboratory Test of Apricot Kernels.—The following tables show the results arrived at:—

	Grms.
Average weight of apricot stone	2·22
Average weight of kernel	0·47
Percentage of kernel in stone	21·35

The kernels, freed from shell, were analysed, with the following percentage results:—

	In Fresh Kernels.	In Dried Kernels.
Moisture	7·08	—
Ash	3·10	3·34
Proteins (N×6·25)	24·39	26·25

The following constants were obtained on examination of the oil:—

Specific gravity at $\frac{15 \cdot 5^\circ C}{15 \cdot 5^\circ C}$	0·9211
Saponification value	179·0
Acid value	1·83
Refractive index at 40° C. (Z.B.R. 58·0)	1·4646
Iodine value	112·0

The percentages of oil above recorded were obtained by ether extraction, but it is evident that cold expression would be a more suitable process, although yielding less oil. Apricot kernel oil, after having been pressed out and allowed to clarify by settling, is almost colourless, but gradually acquires a yellow colour. Its flavour is mild and pleasant. Messrs. Stafford Allen & Sons stated that peach kernel oil was originally imported into Britain from the Continent, and competed in price with true almond oil until its real nature was discovered (*Chemist and Druggist,* Feb. 11, 1905, p. 257). They pointed out that while oil of peach or apricot kernels is a genuine article of its kind, and may be legitimately employed, its surreptitious substitution for almond oil should be discountenanced.

Constants of the Fixed Oils.—It may be well, before passing over from the consideration of the fixed to the volatile oils, to quote some comparative figures arrived at on examination of the fixed oils of the almond, peach, and apricot.

The 1914 British Pharmacopœia lays down the following limits for almond oil:—

Specific gravity	0·915	to	0·920
Saponification value	188·0	to	196·0
Acid value		under	6·0
Refractive index (40° C.) ...	1·4624	to	1·4640
Iodine value	93·0	to	100·0

Andes ("Vegetable Fats and Oils," p. 159) quotes the following constants:—

	Almond Oil.	Apricot Oil
Specific gravity (15° C.)	0·917- 0·920	0·915
Saponification value	187·9 -195·4	192·9
Iodine value	90·4	100·0

Apricot kernel oil, according to Andes, sets at −14° C., while almond oil sets only at −25° C. (−20° C. according to the United States Dispensatory).

Comparing the fixed oil of almonds with that of pea-nuts, Fryer and Weston ("Oils, Fats, and Waxes") give the following averages:—

	Almond Oil.	Arachis Oil.
Specific gravity (15·5° C.) ...	0·918	0·9175
Acid value	—	10·0
Saponification value	192·0	193·0
Iodine value	99·0	90·0
Refractive index (40° C., Z.B.R.)	57·0	55·5
Solidifying point of fatty acids	10·5	28·5

The maxima and minima iodine values, according to the same authors, are as follows:—

Almond oil	98—100
Peach oil	92—109
Apricot oil	101—108

Rogers ("Elements of Industrial Chemistry")

gives the following comparative table:—

	Almond.	Peach Kernel.
Oil content of seed	45-55 p. cent	32-35 p. cent
Specific gravity of oil	0·9175-0·9195	0·9180-0·9215
Refractive index ...	1·4731- (15·5° C.)	1·4713 (15° C.)
Iodine value	100·7	92·3-100·3

Lewkowitsch gives the following constants of apricot kernel oil. No. 2 being from Mogador, and No. 3 from Californian kernels:—

	1.	2.	3.
Specific gravity ...	0·9200	0·9172	0·9203
Saponification value	192·4	198·2	190·3
Acid value	2·3	2·8	1·2
Refractive index (40° C., Z.B.R.)	58·0	57·0	58·0
Iodine value	107·4	107·9	108·7

The following comparative table is compiled from Allen's "Commercial Organic Analysis":—

	Almond Oil.	Peach Oil.	Apricot Oil.
Specific gravity 15° to 15·5° C.	0·914-0·920	0·918-0·920	0·918-0·920
Saponification value ...	287-294	293-297	291
Iodine value	93-101·9	92·5-99·7	100-108

The Essential Oils.—The volatile or essential oils, both of the bitter almond as well as of the peach or apricot (sweet almonds, it will be borne *in mind, do not yield an essential oil*), are derived from their respective sources by processes wholly different from, and subsequent to, those by which the fixed oils are obtained. It is only on treating with water the cake or marc remaining after expressing the fixed oil, leaving it to macerate for 24 hours or more, and then subjecting the mash to distillation, that the volatile oils are obtained. This process, as indicated above, can be applied to either almonds, peach, or apricot kernels, *for in all three cases the* glucoside amygdalin and the ferment emulsin are present, and so benzaldehyde and hydrocyanic acid are formed and distil over when heat is applied. Bitter almonds yield from 1 to 3 per cent of this essential oil. The South African apricot kernels yielded 0·5 per cent.

In the case of apricots the residual cake has been used for feeding poultry and in the manufacture of liqueur.

The following are the characteristic constants of bitter (*i.e.*, essential) almond oil, with and without hydrocyanic acid, according to Parry ("Chemistry of Essential Oils"):—

	Containing Acid.	Freed from Acid.
Specific gravity	1·045-1·070	1·049-1·055
Refractive index ...	1·532-1·545	1·542-1·546

High specific gravity usually indicates the presence of a large amount of hydrocyanic acid, and hence a particularly poisonous oil. These essential oils are much used for flavouring purposes in cookery, and in order to enable them to be so used with safety, they are freed from the extremely poisonous hydrocyanic acid (or prussic acid, as it used to be called), which is present in the distilled essential oil to the extent of about 5 or 6 per cent, or 13 per cent according to the U.S. National Dispensatory. The purification of the essential oil is effected by redistilling it over ferrous hydroxide, *that is to say, a mixture of* lime and ferrous sulphate. So it comes about that two varieties of the essential oils are on the market, one variety containing, and the other freed, from hydrocyanic acid. These two varieties must be most carefully distinguished from each other on account of the very poisonous character of the one. The bitter almond oil freed from hydrocyanic acid is known in the drug trade as "Essential Oil of Almonds, S.A.P." (*i.e., sine acido prussico*). That containing the hydrocyanic acid is, on account of its fairly stable composition, regarded as one of the best forms in which that powerful drug can be administered.

The benzaldehyde, which is the main constituent of the essential oil, gradually absorbs oxygen from the air and changes into benzoic acid, which in course of time appears as a crystalline deposit in the oil, and may accumulate to such an extent as to impart to the oil a semi-solid character.

Artificial oil of bitter almonds is simply benzaldehyde prepared synthetically from the hydrocarbon toluene, one of the products of the destructive distillation of coal, hydrocyanic acid being frequently added to bring it within pharmacopœa requirements.

Essential oil of bitter almonds has been frequently adulterated with or even wholly replaced by synthetic benzaldehyde prepared from toluene. For this purpose toluene is oxidised, according to a *German patent which has been successfully* worked, by means of nickel or cobalt oxide. This synthetic oil is practically as good a flavouring as the genuine essential oil, but it oxidises more rapidly.

In concluson, it will be of interest to record that towards the close of last year a Rotterdam firm made inquiries in Souh Africa for apricot kernels, which they were prepared to purchase at £70 per ton.—*The South African Journal of Industries.*

CHEMICAL RESEARCH FOR THE DEVELOPMENT OF INDUSTRIES IN INDIA.*

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HAVING recently been entrusted with the task of starting a research institute for the Government of the United Provinces, I have naturally been giving considerable attention to the question as to what chemical researches are likely to be most useful for the development of industries in that Province. And as I have been prevented by the circumstances of the case from doing much experimental work, I thought I could not do better, when I was asked to open a discussion at the Indian Science Congress on a chemical subject, than invite discussion on the same subject, widening the field to the whole of India. At any rate, I feel sure that I am opening a discussion on a subject or group of subjects which is of great interest to many members, and I hope that I shall

*An Address read at the Calcutta Meeting of the Indian Science Congress, on February 1, 1921.

learn a great deal from the discussion which will follow.

On attempting to answer the question I have proposed, viz., what chemical researches are most urgently required and most likely to lead to important industrial developments in India, one feels that a somewhat wider question must first be tackled; namely, what industries involving chemistry are most capable of development or likely to develop in India. The two problems are not synonymous, as there may be industries involving chemistry which are capable of large and successful development in this country without the assistance of chemical research or with very little assistance. Again, this second question, as to what industries involving chemistry are capable of development, is evidently part of a still wider question, viz., that of the industrial development of India as a whole. I do not intend rigidly to separate these different questions. My object is to promote useful discussion.

I should like first to mention the chief contributions which have already been made to this subject. The United Provinces Government was early in the field, as in 1907 it considered the establishment of a technological institute at Cawnpore, of which one of the main functions was to be chemical research for the promotion of industries: and in several official communications it gave its views as to what chemical researches were most urgently required and most likely to be useful.

The Industrial Commission's report (1918) has a chapter on the deficiencies in Indian industries. It points out the order in which industries have developed in other countries, viz., iron and steel manufacture first, then the production of textiles and similar goods by machinery, then the manufacture of chemicals required in these large-scale industries. It points out India's deficiency in iron and steel production which has retarded the proper development of many industries dependent on machinery. It says, "the incompleteness of our existing system of industries has been brought into prominent notice by the interference with industrial supplies from overseas due to the war. This constitutes a serious natural danger, the extent and gravity of which will be more clearly realised if we refer in detail to some of the more important manufactured materials or articles which are not at present made in India, although the basis for their production exists in the form of raw materials." The following materials and articles are then mentioned: zinc, copper, tungsten, and other ingredients of high-speed steels, chromium, graphite, thorium salts for incandescent mantles, caustic soda, benzol and related products, rubber goods, tin plate, paper, drugs, dyes, essential oils. It is remarked that "in the absence of any means for producing from purely Indian sources, sulphuric, nitric, and hydrochloric acids and alkalis, our manufactures, actual or prospective, of paper, drugs, matches, oils, explosives, disinfectants, dyes, and textiles are dependent upon imports which under war conditions might be cut off." Yet "sources of raw materials for heavy chemicals are not deficient."

Drs. Sudborough and Simonsen have discussed chemical industries in the late Indian Munitions Board's Industrial Handbook (1919). They there laid down the general principle that in any attempts to foster the development of chemical industries in India, attention should be directed, in the first instance, to industries which make use of the Indian-grown raw materials now exported to other countries. Included in these exports are (1) the raw materials from which important fixed oils and feeding cakes are manufactured; (2) the raw materials from which valuable essential oils and medicinal drugs are prepared; and (3) various mineral products, such as chrome, manganese, and zinc ores, wolfram, and monazite sands. It is, however, admitted that the proposition of making India an oil and oil-products exporting, rather than an oil-seeds exporting, country is not a simple one. In addition to such industries, it is recognised that the manufacture of heavy chemicals is a key industry or group of key industries; and, as to their prospects, it is considered, firstly, that the manufacture of sulphuric acid from zinc concentrates is promising; secondly that sufficient nitric acid for some time to come can suitably be obtained from Indian nitre (the utilisation of atmospheric nitrogen is considered to be a proposition requiring careful consideration), and, thirdly, that it is doubtful whether sufficient soda to meet all Indian requirements can be obtained by the extraction of alkaline soils. The cost of the ammonia soda process would probably be too heavy to permit of soda manufactured by this process competing with imported carbonate in normal times. The electrolytic production of caustic soda and soda ash could only be made a success by utilising the bye-products, and Magadi soda is likely to be a dangerous competitor with the Indian manufactured article; but, nevertheless, alkalis are so important that it may be necessary to protect their manufacture. It is considered essential to manufacture chlorine and bleaching powder in India.

As to the manufacture of explosives, synthetic dyes, drugs, &c., from coal-tar, it is considered that the amounts of tar available in India at present are quite insufficient to start a large coal-tar industry, and that the only way to start such an industry would be to coke all suitable coal at the pithead.

The manufacture of permanganates, chromates, and lead products, such as litharge, red lead, and white lead, are all considered to be eminently practical propositions.

Wood distillation is regarded as rather a doubtful proposition, owing to the existence of large supplies of its products and the low prices likely to prevail for some time after the war.

The Indian Munitions Board held a conference of chemists in 1918 and organised as far as possible chemical research work on industrial problems. Their list of chemical researches which have been taken up includes very little under the head of heavy chemicals; it includes a good many researches on Indian oils, such as *neem, mahva, til,* fish oils, the hardening of oils, the manufacture of glycerin and varnishes, the utilisation of new Indian tanning materials and preparation of tanning extracts; the preparation and refining of essential oils, such as rose, patchouli, retivert, lemon-grass, clove, cardamom; the manufacture of strychnine, atropine, and caffeine, the manufacture of chromates, wood-distillation, and various problems which are not touched on in the chemical industries article in the Handbook, such as

the manufacture of starch, alcohol, and glue.

The Chemical Services Committee (1919-20) have expressed the opinion that India is deficient at present in raw materials for the production of organic chemicals from coal, but consider that there is an enormous field for the production of carbon compounds from vegetable products. They explain that they do not only refer to such products as *oils from oil-seeds, indigenous dyes*, drugs, and essential oils, but consider that there is a great field for the production of new products of greater economic value by the conversion of organic compounds present in Indian plants.

From these references to what has already been said on the subject it is obvious that the subject can be looked at from several points of view. In the first place, it may be argued that, as India is *essentially an agricultural country, exporting* large quantites of agricultural products, the most obvious industrial development is to carry out in this country the processes to which those products are at present submitted on arrival at their destination. This argument recommends the pressing of oil seeds, the manufacture of soap, glycerin, and varnishes, the tanning of hides and skins, the extraction of alkaloids and so on. In the *second place, it may be argued that industries* are bound to develop in all countries according to a definite sequence; iron and steel first, then machinery, then the textile and similar industries, and then the chemical industries to meet the requirements of these. In the third place, the great war has brought into prominence the disadvantage at which a country may be placed unless it is self-supporting as regards essentials, such as food and *clothing and munitions of war. From this* point of view it may be necessary for the State to protect and foster certain key industries.

At first sight it appears as though these different arguments might lead to different recommendations as to the chemical industries which should first be developed in India. If this is the case, it is obvious that there is something wrong with one or other of these general principles. But I think I shall be *able to show that when carried* to a conclusion all the arguments lead to the same recommendations. My own employment during the war, when I had the pleasure of helping in the British manufacture of synthetic dyes, naturally makes me inclined to look on the problem of Indian industrial development from the last point of view, viz., to see that key industries are placed on a satisfactory footing. Fortunately, India is essentially self-contained as regards foodstuffs and textile fibres; but she is by no means self-contained as regards military requirements, such as explosives and synthetic dyes. This points to the desirability of establishing the coal-tar industry in this country; for it is from coal-tar that all countries obtain high explosives, their synthetic drugs and their synthetic dyes. The war has taught us how intimately inter-connected are the manufacture of these three groups of chemical products. I find, however, that most chemists who have given their attention to the development of Indian industries discourage the idea of attempting the manufacture of explosives, drugs, and dyes from coal-tar. They say India does not produce sufficient tar; the tar is deficient in the most valuable ingredients; it is doubtful whether England will succeed in manufacturing these products in the face of German competition, and so it would obviously be absurd for India to try.

Let us take first the most obvious military necessity, viz., explosives. What quantity of explosives does India consume? What quantity is she likely to require in the event of war? How much does she manufacture at present and how much does *she import? I have not got any official returns* as to production and consumption, but I calculate that India is producing less (probably far less) than 4000 tons of explosives annually, and importing less (probably far less) than 5000 tons. I have arrived at the figure for India's production of explosives from the total consumption of nitrates and nitric acid in the country. The majority of the nitrates are no doubt used as *manures, so that my figure is the maximum possible*, which is probably many times greater than the actual. And for India's imports of explosives I have had to go by the figures for imports of explosives as private merchandise *plus* total Government import of arms, ammunition, and military stores, excluding firearms. Here, again, my figure is the outside limit which is probably far greater than the actual figure. But these figures *are no higher than the most moderate estimate of* India's probable requirements in the case of war. Before the war England produced 18,000 tons of explosives annually. By 1916 the amount had risen to 200,000 tons, and by the end of the war to about 350,000 tons. As we are on the subject of coal-tar, let us consider first those explosives which are manufactured from coal-tar, *i.e.*, high explosives, such as picric acid and T.N.T. *Ammonium nitrate is also very important and can* also be manufactured in connection with the coal-distillation industry. During the war England produced about 1,500 tons of picric acid and T.N.T. a week, as compared with 2500 tons of propellants, such as cordite, and 3000 tons of ammonium nitrate. As a most modest estimate, we may assume that India should be able to produce 4000 tons of picric acid and T.N.T. per annum, *and might require many times that amount.*

At present India makes about 500,000 tons of coke and 8000 tons of tar per annum. It is estimated that, if all the coke were manufactured in bye-product recovering plants, about 16,000 tons of tar would become available. This is a low figure, based on a note prepared by Mr. W. J. Alcock for the Indian Munitions Board. I think it is probably based on practice in the Bengal *Iron and Steel Company's coking plant. It is* well-known that the yield of tar depends very much on conditions of coking, so that too much importance should not be attached to the low yield. But as the benzene and toluene content of tar is only about 1 per cent, we could not get more than 80 tons of benzene and toluene a year if all the tar at present produced were distilled for this purpose. The amounts of tar available *in India under present conditions are obviously* quite insufficient to produce all the explosives required. But Drs. Sudborough and Simonsen estimate that, if scrubbing plant for recovering benzene and toluene from the coke-oven gases were introduced, an additional 2,000,000 gallons, or about 10,000 tons, of crude benzol could be obtained. With this quantity of crude benzol available, the manufacture of high explosives be-

comes a practical proposition. Drs. Sudborough and Simonsen's estimate of 10,000 tons of crude benzol from plant producing 500,000 tons of coke is high, but, even during the war, the yield of crude benzol has been much increased by improved washing. According to the *Proceedings of the Institute of Civil Engineers* for March, 1918, 13·5lb. of benzene and toluene can be obtained from one ton of coal. Calculating from this figure, plant producing 500,000 tons of coke could yield *nine million pounds*, or *about one million gallons*, of benzene and toluene. This quantity of benzene and toluene would suffice to produce the quantity of explosive which we calculated as India's minimum safe production. In peace these hydrocarbons could be utilised largely for the production of dyestuffs. The Germans showed during the war the close connection between the manufacture of explosives and synthetic dyes and drugs. Plant used in peace time for manufacturing dyes can readily be turned in war time to the production of explosives. Germany's large dye manufacturing concerns were so employed during the war. India's maximum annual importation of dyestuffs was 8000 tons. This is a figure of about the same order as her requirements in the way of explosives and her present productive capacity in the way of benzene and toluene *from her coking operations*. Her production of iron and steel is bound to increase. Her coal resources have not yet been fully exploited and she already produces 20 million tons per annum. The amount of iron ore and other requisites for iron and steel manufacture are unlimited. India produces at present about 250,000 tons of iron and steel and imports 1¼ million tons annually. If she produced only as much as she now requires the blast furnaces would consume at least 1½ million tons of coke, and this would at once triple the possible production of benzene and toluene.

My calculations may be wrong, but so far as benzene and toluene are concerned, I think India is in a sound position to undertake the manufacture of explosives, synthetic dyes, and drugs.

Nor is India by any means dependent on her coking ovens for a sufficient supply of aromatic hydrocarbons to manufacture all the explosives and synthetic dyes she may need. During the war a good deal of attention was given to the production of these hydrocarbons from petroleum, and it is now recognised that this is a practical proposition. Ordinary scientific literature contains very little information on the subject. But in 1907 Jones and Wootton pointed out in the *Transactions of the Chemical Society* that Borneo petroleum contains a considerable quantity of aromatic hydrocarbons, and we learn from a paper in the *Journal of the Society of Chemical Industry*, 1919, that a source of supply of toluene for British explosives was developed during the war by the Asiatic Petroleum Co. from Borneo spirit. The third volume of the Society of Chemical Industries' Annual Reports informs us that in Russia aromatic hydrocarbons for dyes and explosives have long been obtained by cracking petroleum oils. Nikiforoff took out patents on this subject in 1886, 1887, 1901, and 1902. In the United States of America, also, a great deal of attention was paid during the war to the production of aromatic hydrocarbons by cracking petroleum.

Mention has already been made of the Chemical Services Committee's suggestion that some of the *numerous organic compounds produced so freely* in the vegetable world in India could be subjected to a variety of chemical processes to yield a range of chemical products. Explosives and dyes might be produced in this way, *e.g.*, tannins are produced in India in enormous quantities in barks, fruits, &c. Ordinary tannin or tannic acid is converted quantitatively into gallic acid on hydrolysis. Gallic acid is said to be converted quantitatively into salicylic acid or benzoic acid by reduction with zinc dust and ammonia (Guignet, *Bulletin de la Société Chimique*, (3), 7,158). These substances might serve as starting-out materials for the preparation of explosives, dyes, &c. I do not wish to be more explicit at present, but I may say that experiments I have in hand have already shown that aromatic hydrocarbons, ample for India's requirements in the way of explosives, dyes, and drugs, can be obtained conveniently and cheaply from indigenous materials other than coal distillation bye-products. I hope shortly to patent these methods of production and get them taken up on a large scale. Private firms of explosive manufacturers have already been considering the manufacture of high explosives in India.

It may, however, be argued that the successful manufacture of explosives, synthetic dyes, and drugs, requires not only a sufficient supply of cheap aromatic hydrocarbons but many other chemicals in considerable quantity, such as sulphuric acid, nitric acid, caustic soda, alcohol, wood spirit, formaldehyde, chlorine, nitrite, zinc, ammonia, &c., and that the want of these renders impracticable any proposition for manufacturing dyes and explosives in India. Let us consider these chemicals in detail.

Sulphuric Acid.—The manufacture of this acid has up to the present been seriously handicapped by the absence of suitable sulphides for roasting, and imported sulphuric has been used. India's present consumption of sulphuric acid is somewhere between 10 and 40 thousand tons per annum.

Owing to the importance both of sulphuric acid and zinc "the Government of India is interesting itself in the proposal to erect zinc-smelting works at Jamshedpur, where the zinc concentrates from Bawdwin in Burma will be dealt with and the spelter and sulphuric acid yielded made available to the Tata Iron and Steel Co. for their own purposes and for subsidiary companies. The plant, which it is proposed to erect with a loan from Government, will be capable of dealing with 25,000 tons of zinc concentrates, and the estimated output is 10,000 tons of spelter per annum" (Cotton, "Handbook of Commercial Information for India," p. 234) and 32,000 tons of sulphuric acid. The iron and steel industry requires large quantities of sulphuric acid for recovering ammonia from the coking plant and for pickling iron plate for galvanising and tinning. Most countries consume very large quantities in the manufacture of superphosphates. There is no reason to fear that the production of sulphuric acid will exceed the demand, but it should meet all requirements for some time, including requirements for the manufacture of explosives and

dyes. I have no information as to the amount of zinc concentrate which may eventually become available. At present this scheme has a serious defect from the military point of view, as a blockade of the Bay of Bengal would cut off the supplies of zinc concentrates. A railway from Burma to India is in contemplation, but I do not know whether it is likely to be built immediately. It seems remarkable that it should be necessary to go over-seas, even as far as Burma, for sufficient suitable sulphur compounds for the manufacture of sulphuric acid. During the war the German Government is said to have subsidised heavily an enterprise for the manufacture of sulphuric acid from gypsum (*Journal Soc. Chem. Indus.*, 1916, 1058; U.S. Pat. 1197331, Sept. 5, 1916), and it is stated that sulphuric acid can be manufactured in any quantity by this process at the same cost as from imported pyrites. On consideration, it seems almost certain that in any country the bulk of the element sulphur will be in the form of sulphates. Sulphides are essentially unstable compounds, and on weathering are converted with sulphates. It is certain that there are sufficient natural sulphates in India to supply all the sulphuric acid likely to be required either now or in the future. I hope shortly to take out patents for the manufacture of sulphuric acid from readily available natural sulphates.

Nitric Acid.—At present India exports about 26,000 tons of nitre, consumes about 4000 tons, and imports about 1700 tons of Chili saltpetre. Her imports of nitric acid are negligible. With a sufficient supply of sulphuric acid there will be no difficulty about producing the nitric acid required for explosives and dyes.

Caustic Soda.—The quantity of alkalis required for the manufacture of dyes and explosives is comparatively small, and India's requirements in this respect could easily be met from the salts contained in alkaline soils. Drs. Sudborough and Simonsen's remarks on the question of alkali manufacture have already been quoted at some length. That it is a key industry there can be no question. The present consumption of alkalis is comparatively small (35,000 tons of soda imported in 1917-18) but increased production of cotton goods and soap is bound to multiply many times the present demand for alkalis. An increased demand for cotton goods is one of the most certain results of India's development, and, with an increase in the production of iron and steel and machinery, there is no doubt that increasing quantities of cotton goods will be manufactured in this country. The present value of cotton goods consumed per head of the population is Rs.2-12 per annum. There can be no doubt that this will be multiplied several times in the near future, and that the bulk of the goods will be manufactured in this country. This will increase proportionately the demand for alkalis, which are used for scouring cotton goods.

It is doubtful whether it will be feasible to get all the alkalis required from alkaline soils. Mr. Srivastava, Industrial Chemist to the United Provinces Government, estimated that 5000 tons of soda ash per annum could easily be obtained from *reh* soils near Cawnpore. There are large tracts of such soils in the United Provinces and the Punjab, and there would be no difficulty in manufacturing all India's alkali requirements from these soils if Mr. Srivastava's estimate is correct. On the other hand, I hear that a recent survey by the Geological Department of the alkaline earths of Rajputana gave disappointing results, although these soils have generally been considered a more suitable source of soda than the soils of the United Provinces and the Punjab. Some more quantitative information about the alkaline soils of the United Provices and the Punjab is urgently required to decide the lines on which this key industry must develop.

Alcohol.—As India is essentially an agricultural country and exports large quantities of material, such as grain, which are used in the country of destination for the production of alcohol, there seems no reason to doubt that industrial alcohol could be successfully produced in India. Dr. Fowler's selection of *mahua* flowers as the most suitable starting-out material has been criticised, but I have not time at present to discuss his point.

Wood Spirit, Formaldehyde, and Acetic Acid.—I have already mentioned that the writers of the article on chemical industries in the late Indian Munitions Board's Handbook look on wood-distillation in India as a somewhat doubtful proposition, on the ground that very large plants for wood-distillation were set up for war purposes and will flood the post-war market with wood spirit and acetic acid at low prices. But these products are all dangerous chemicals, and shipping freights on them are very high, so that a comparatively small plant meeting India's requirements would possibly be a sound proposition, although manufacture on a large scale for export might not be feasible.

I hope I have said enough to show that we do not really arrive at different conclusions by approaching from different points of view the problem of the development of India's chemical industries. If we start with the idea that the first and most obvious thing to do is to work up our vegetable products to a certain extent before export, we find that to do this we want cheap acid, alkalis, spirit, &c. If we start with the idea that there is only one possible sequence of development of industries which has been followed in all countries which have developed, and must be followed in all countries which are developing, viz., iron and steel manufacture first, then machinery, then textiles, &c., with chemical industries as hand-maidens called in as required, we find again that cheap acids and alkalis are the first chemical requirements, and the manufacture of explosives, dyes, and drugs, necessarily follows for the utilization of by-products and to meet the requirements of the textile industry. If we start with the idea that first and foremost we must see that India's military requirements are met so that she could withstand a blockade, then we decide that explosives must be manufactured in the country from materials all available in the country. This leads again to the necessity for developing the iron and steel industry, for the manufacture of acids and alkalis, the utilisation of coking bye-products and the manufacture of dyes and drugs along with the explosives.

I find that I have spoken chiefly about the development of chemical industries in India and

very little about chemical research for the development of industries. But that seems to me the proper way of looking at the subject. First let us decide what has to be done, and then let us see how chemical research may assist. At first it may seem that there is not much need for research to instal in India such well-known industries as the manufacture of iron and steel, sulphuric acid, alkalis, coking bye-products, &c. But my discussion of these problems has already suggested several researches, *e.g.*, the question of the utilisation of sulphates for the manufacture of sulphuric acid, a survey of India's alkaline soils, and the possibility of finding other sources than coal-tar and coke-oven bye-products for the manufacture of aromatic compounds, such as explosives, dyes, and drugs. These are researches for the decision of most important and fundamental questions. The establishment of any manufacture involving chemical reactions on a large scale is much assisted by chemical research.

Problems are certain to arise from the fact that the materials available, or climatic conditions, or other factors, are different from those in the countries already carrying on these manufactures. These are platitudes which the British find it hard to recognise, but which are, nevertheless, recognised to a greater extent than before the war. So far I have spoken of research in connection with the fundamental industries. For others which are not, perhaps, of such vital importance, there are any number of chemical problems appealing, perhaps, more strongly to the chemist, whose interests are primarily scientific, *e.g.*, lac-dye is thrown away at the present time. Apparently the fastness to alkalies of its dyeings is not quite good enough to meet modern requirements, but it is an anthraquinone derivative, and so belongs to the same family as our most valuable mordant and vat dyes. Comparatively simple chemical treatment might convert it into a valuable dye. In Indian turpentine we have a cheap source of pinene in any quantity. The chemical relationship between the different members of the terpene group is very close, and it seems quite feasible to convert pinene into the unsaturated open chain compounds which are the chief constituents of essential oils and perfumes. Amongst the vegetable products of India the organic chemist can find any number of problems of interest, and very likely of profit.—*Journal of Indian Industries and Labour*

NEW BRITISH CHEMICAL STANDARDS
(ANALYTICALLY STANDARDISED SAMPLES).

ANOTHER new plain carbon steel is now ready for issue, *viz.*, "R," which fills the vacancy in the series for a carbon standard between "I" (carbon 0·521 per cent) and "SI" (carbon 0·921 per cent). It is also intended to serve as a high manganese standard and a sulphur standard in high carbon steel. The analyses have been undertaken as usual by a number of experienced chemists representing the following interests: British Government Dept.; U.S. Bureau of Standards; Referee Analysts, independent; Railway Analysts, representing users issuing specifications; Works Analysts, representing makers and users.

The standard figures are as follows:—

Carbon Steel "R."

Carbon (combustion)	0·786
Carbon (colorimetric)	0·790
Silicon	0·22*
Sulphur, total by oxidation ...	0·053
Sulphur, evolved as sulphide ...	0·050
Phosphorus	0·058*
Manganese	0·914
Arsenic	0·03*
Copper	0·02*
Ni, Cr, W, Mo ...	None detected by qualitative tests.

* Approximate.

The standards may be obtained in 500, 100, or 50 grm. bottles, either direct from Organising Headquarters, 3, Wilson Street, Middlesbrough; or through any of the leading laboratory furnishers at a price just sufficient to cover the cost. A certificate giving the names of the analysts co-operating, the types of methods used, and a detailed list of the results will be supplied with each bottle.

NOTICES OF BOOKS.

Technical Methods of Analysis. Edited by ROGER CASTLE GRIFFIN. First Edition. Pp. xv.+666. London: McGraw-Hill Book Co. Inc. Price 33s.

This book contains a comprehensive selection of practical methods of analysis which have, with a few exceptions, been tested and adopted in the laboratories of Arthur D. Little, Inc., one of the best-known firms of consulting chemists in the United States.

Some of the methods described are original, but most of them are already well-known, many of these, however, have been more or less modified in the light of experience gained through many years of practice. After dealing with the methods of preparation and the strengths of reagents, volumetric solutions and indicators, there follow chapters on the analysis of inorganic and organic materials of a general nature. These are followed by chapters each dealing with a special class of materials such as metals, fuels, paints, oils, wood and paper, textiles, and foodstuffs.

Miscellaneous analyses include such materials as case-hardening compounds, metal polishes, and road-making materials.

Analyses of drugs, alkaloids, minerals, &c., which are generally dealt with by specialists in these particular branches of chemistry are not included in the book, which is intended for those engaged more in the general run of work in a commercial laboratory.

The methods are described in a direct and practical manner, no attempt having been made to prove their accuracy by means of experimental data nor to explain the theory of the procedure.

The book is completed by a series of analytical tables newly calculated from the 1920 International Atomic Weights, and a good bibliography of books and pamphlets which has been found to be of great value in the laboratory.

Fundamental Principles of Organic Chemistry. By CHARLES MOUREU, Member of the Institute and of the Academy of Medicine, Professor at the College de France. Authorised translation from the Sixth French Edition by WALTER T. K. BRAUNHOLTZ, B.A., A.I.C. With an introduction by Sir WILLIAM J. POPE, K.B.E., F.R.S. London: G. Bell & Sons, Sons, Ltd. Price 12s. 6d. net.

In the introduction by Sir William Pope, it is stated that the student who desires an intelligent acquaintance with Organic Chemistry must be so steeped in the various modes of presentation of the subject, guiding principles become an instinct with him, and that bias toward the adoption of any specific classificatory system disappears. For this reason the translation of the work of Prof. Moureu, who is one of the foremost of French organic chemists, will be welcomed by English students.

The work of the author has been fully appreciated in France, having run into six editions within a very short time. The translator draws attention to the fact hat he has very closely followed he sixth edition, except in the mater of nomenclature, substituting the English system for that of the Geneva Congress, which is largely used in the original. The author's method of teaching and his individuality is by no means lost in the translation.

In spite of the magnitude of the subject, the work is encompassed in less than 400 pages, and is well printed by William Clowes & Co.

CORRESPONDENCE.

THE BATTLE OF JUTLAND FILM.

To the Editor of the Chemical News.

SIR,—A number of cinema proprietors, who are about to show above picture, are desirous of engaging the services of Jutland survivors who are willing to speak to the film when it is being exhibited. As proprietors of the picture in question, we are prepared to make a register of all such men, if they will be good enough to send us their names and addresses as well as their rank and the name of their ship. We will put them in touch, in each case, with the nearest cinemas showing the picture.

As this is the only means we have of reaching the survivors of the Battle, we shall esteem it a great favour if you would be so good as to grant us the courtesy of your columns.—I am, &c.,

H. ROWSON,
Managing Director, Ideal Films, Ltd.

NOTES.

FARADAY SOCIETY.—A General Discussion on "Catalysis with special reference to Newer Theories of Chemical Action" will be held under the auspices of the Faraday Society, on Wednesday, September 28, at the Institution of Electrical Engineers, Victoria Embankment, W.C.2. The Discussion will be divided into two parts: Part I. beginning at 4.30 p.m., will deal with the "Radiation Theory of Chemical Action," and it will be opened by Prof. J. Perrin, of Paris. The second portion of the Discusson will concern itself with "Heterogeneous Reactions," and it will be opened by Prof. Irving Langmuir, Chief Research Chemist to the General Electric Company, U.S.A. It is expected that Prof. Arrhenius and Prof. Victor Henri will also be present, and among others who will contribute to the Discussion are Prof. E. C. C. Baly, Prof. F. G. Donnan, Prof W. C. McC. Lewis, Prof. A. Lindemann, Prof. A. W. Porter, and Dr. E. K. Rideal. Fellows of the Chemical Society are invited to attend this meeting. Others interested in the subject may obtain tickets of admission from the Secretary of the Faraday Society, 10, Essex Street, London, W.C.2.

NORTHAMPTON POLYTECHNIC INSTITUTE.—The new session in the evening courses and classes will start on September 26, and the day courses and classes a week later. The entrance examinations for the latter will he held on the 27th and 28th instants. Last session marked the resumption of full work in all departments of the Polytechnic on the conclusion of the war. The enrolments being more numerous, in all courses and classes than in any pre-war session, many applicants for evening work had to be placed on the waiting lists. It may now be taken that all the classes are in their full pre-war stride, only more so. Very substantial additions were made to the equipment during the last session, owing to a liberal grant of the London County Council. During the disturbance caused by the war, the equipment could not be kept up to its usual high and up-to-date standard, and although it cannot be said that in all directions the well-known character of the equipment has been resumed, a very good start has been made in supplying the deficiencies, both in the engineering departments proper, but more especially in the department of optical engineering, and applied optics. A further grant has been made by the London County Council, which will be expended during the current session in dealing with the most urgent needs.

X-RAYS IN INDUSTRY.—A correspondent of the *Manchester Guardian Commercial* in this week's issue refers to the use of X-rays in industry. He says the public know little of the manner in which Rontgen rays were made use of during the war in locating hidden defects in materials used for important purposes, such as the building of aeroplanes. At the moment industrial radiology is young, and care must be taken not to claim for it too much at such an early stage. Nevertheless, it has already shown that its possibilities outside the range of surgical applications are boundless, and for that reason the establishment of an Institute of Radiology in London is a project which deserves every possible support.

MR. S. HORWOOD TUCKER, M.Sc., has been appointed to the Lectureship in Organic Chemistry in the University of Glasgow.

SAFEGUARDING OF INDUSTRIES ACT.—In accordance with Section 7 of the Safeguarding of Industries Act, the President of the Board of Trade has appointed the following gentlemen to be members of the permanent panel from which Committees, consisting of five persons, will be selected from time to time to consider and report upon complaints referred to them by the Board under Part II. (Prevention of Dumping) of the Act: Sir W.

M. Acworth, J. Arthur Aiton, Esq., C.B.E., Sir William Ashley, Arthur Balfour, Esq., J.P., Sir George S. Barnes, K.C.B., K.C.S.I., Sir John N. Barran, Bt., J. T. Brownlie, Esq., Sir Cecil L. Budd, K.B.E., Sir James C. Calder, C.B.E., Dr. J. H. Clapham, O.B.E., T. P. Cook, Esq., F. R. Davenport, Esq., A. K. Davies, Esq., F. P. Dorizzi, Esq., Rayner Goddard, Esq., Sir E. C. K. Gonner, K.B.E., Sir George R. Lowndes, K.C.S.I., K.C., Prof. D. H. Macgregor, Stanley Machin, Esq., J.P., G. A. Moore, Esq., J. W. Murray, Esq., D.L., Sir Douglas Newton, K.B.E., Owen Parker, Esq., C.B.E., J.P., R. G. Perry, Esq., C.B.E., Arthur Pugh, Esq., Sir R. Henry Rew, K.C.B., C. A. Russell, Esq., K.C., Arthur Shaw, Esq., Sir Charles Stewart, K.B.E., Sir Edwin F. Stockton, J.P., H. L. Symonds, Esq., Gilbert C. Vyle, Esq., Sir Frank Warner, K.B.E.

PRICKLY-PEAR FRUIT.—The tuna, or prickly-pear fruit, is said to contain on an average about 10 per cent of sugar directly and completely fermentable into alcohol, and according to investigations carred on in the New Mexico College of Agriculture, a yield of 10 tons of fruit per acre was estimated, but the difficulty in the way of practical application was the lack of some economic method of collecting the fruit. Hand-picking is not considered sufficiently expeditious, and a machine for collecting large yields of fruit from small areas was looked upon as essential. The amount of sugar in the fruit may vary from 5 to 15 per cent, mainly in the form of reducing-sugar (dextrose). It has been found that fruit which contained 7 per cent of sugar in August (U.S.A.) increased its sugar-content within a month to 12 per cent. The theoretical yield of alcohol from 100 kilogrms. of dextrose is 51·1 kilogrms., corresponding to 64·4 lirres, so that 10 tons of prickly-pear tunas, carrying 10 per cent of sugar, would yield 1022lb., or 128 gallons from one acre. Those who carried on the above investigation reckoned that the cost of producing alcohol from prickly-pear tunas would not exceed 7½d. per gallon in a distillery producing 500 gallons of 90 per cent alcohol per 24 hours. Estimating the cost of such a distillery at something over £3000, with a 10-years' life-period, its annual cost was put down as £625. A 60-day season would result in 30,000 gallons of 90 per cent alcohol, depreciation and interest being allowed for at 5d. per gallon of alcohol. For such a factory, assuming 100lb. of fruit to produce 5lb. of alcohol, 2100 tons of fruit would be needed during a two-months season, that is to say, the harvest of about 200 acres. From the above it would appear that between 140 and 150lb. of the tunas would yield 1 gallon of alcohol: at 1s. 8d. per gallon, 1 short ton of fruit would, therefore, be worth about 22s. for alcohol production. If 150lb. produce 1 gallon at the above price, about 8½d. would be available to pay for every 100lb. of fruit and for manufacturer's profits. If the fruit cost 7½d. per 100lb., the fermentation of 2100 tons in 60 days would yield a profit of £145 16s. 8d. over and above the 10 per cent interest on the investment. A yield of 10 tons of tunas, if sold at 7½d. per 100lb., would bring in £6 5s. per acre, which is considered to be a good return for otherwise worthless land, and entailing little or no cultivation.

New Patents.

THIS List is specially compiled for the *Chemical News* by Messrs. Rayner & Co., Registered Patent Agents, of 5, Chancery Lane, London, W.C.2., *from whom all information relating to Patents*, Trade Marks and Designs can be obtained gratuitously.

Latest Patent Applications.

22885—British Thomson Houston Co.—Chemical apparatus. August 29.
23286—Cassela & Co.—Manufacture of salts of acridinium compounds. September 1.
23354—Steinhilber, H.—Process for producing cellulose, from cyperacaes, graninaes and typhacaes. September 2.

Specifications published this Week.

136564—Hansgirg, F.—Method of obtaining perylene.
145085—Mond, A. L.—Process for treating salamoniac skimmings.
157971—Wallin, E.—Method of treating a stonelike material including wood saw-dust from magnesium and magnesium salts.

Abstracts Published this Week.

Ammonium Sulphate.—Patent No. 166036.—Mr. G. P. Heisch, of *Brentford Gas Co., Southall, Middlesex, has designed and patented*

FIG. I.

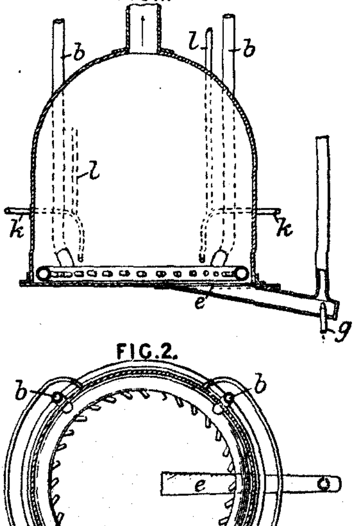
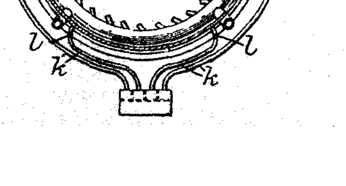


FIG. 2.



an improved ammonium sulphate saturator, which is illustrated in accompanying drawing. It is constructed with a flat bottom and contains no pipes or apparatus except means for introducing the ammoniacal gases. The latter enter through a number of jets which discharge tangentially, and in the same direction from a circular feed-pipe. The ammonium sulphate crystals collect in the vortex which is produced and are withdrawn by means of a pipe leading from the middle, of the bottom of the saturator to an ejector situated outside. In the apparatus shown, ammonia is introduced through the pipes *b*, and acid through the pipes *k*, which are provided with vents *l*, to enable gas generated in the pipes, or air sucked in with the acid, to escape. The ammonium sulphate passes down the slot *e* to the ejector *g*.

Amino Compound.—Patent No. 166283.—Mr. D. A. Legg, of 17, Pepys Road, Raynes Park, and M. A. Adam, of 57, Lincoln's Inn Fields, London, have patented an improved process for the preparation of Amino Compounds. They are prepared by passing nitro compounds such as *nitrobenzene* and nitrotoluene, in the vapour phase and together with hydrogen, water gas, etc., over or in contact with the copper catalyst described in Specificati n 166,249; or in the place of hydrogen as such, there may be employed a body such as secondary butyl alcohol, which is capable of being dehydrogenated under the conditions suitable for the reduction of *the nitro compounds, in which case there is obtained in addition to* the amino compound, methyl ethyl ketone, or if methyl alcohol is employed the reaction product of formaldehyde and aniline. The catalyst is revivified by heating in air to temperatures between 300 and 1000° C.

Messrs. Rayner & Co., will obtain printed copies of the published specifications and will forward on post free for the official price of 1/- each.

NOTICES.

EDITORIAL.—All Literary communications and Books, Chemica Apparatus, &c., for review or notice to be addressed to the EDITOR.

SUBSCRIPTIONS, £1 12s. *per annum, payable in advance, should* be addressed to the MANAGER.

BACK NUMBERS and VOLUMES can be purchased on application to he MANAGER.

THE CHEMICAL NEWS,
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63, LUDGATE HILL, LONDON, E.C.4

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MICHAELMAS TERM COMMENCES SEPTEMBER 26th.

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DEPARTMENT OF INDUSTRIAL CHEMISTRY.
Head of Department—H. W. WEBB, M.Sc., F.I.C., F.C.S.

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(with University College of South Wales and Monmouthshire).
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Examinations which are also catered for by the course include:—
B.Sc. (Lond.) Ext.
Associate Institute of Chemistry.
F.I.C. in Chemical Engineering.
The Session commences on October 4th, 1921.
Fees, 16 guineas per annum plus registration fee and a charge for apparatus.
Further particulars may be obtained on application to the Principal.
JOHN J. JACKSON, B.A., Director of Education, City Hall, Cardiff.

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Salary:—£300 per annum.
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Applications, together with full statement of qualifications and the names of at least three referees, should be sent not later than October 7th, 1921, to the SECRETARY of the University, Marischal College, Aberdeen, from whom further particulars may be obtained.
H. J. BUTCHART, Secretary.

THE owners of British Patent No. 104,658 entitled:—
"BAKING POWDERS",
desire to dispose of the Patent and would be willing to grant a licence to firms likely to be interested or would sell the Patent outright.
A copy of the specification and particulars may be obtained from HERTFORD RECORD CO., Ltd., of LINDSEY HOUSE, 59, LINCOLN'S INN FIELDS, LONDON, W.C.2.

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THE CHEMICAL NEWS.
VOL. CXXIII., No. 3207.

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

EDINBURGH, 1921.

PROBLEMS OF PHYSICS.

ADDRESS DELIVERED BEFORE SECTION A (MATHEMATICS AND PHYSICS)

By PROFESSOR O. W. RICHARDSON, D.Sc., F.R.S., President of the Section.

MY predecessor in office a year ago reminded you that the theoretical researches of Einstein and Weyl suggest that not merely the material universe, but space itself is finite. As to the probabilities, I do not wish to express an opinion; but the statement is significant of the extent of the revolution in the conceptions and fundamental principles of physics now in progress. That space need not be infinite has, I believe, long been recognised by geometricians, and appropriate geometries to meet its possible limitations have been devised by ingenious mathematicians. I doubt, however, whether these inventive gentlemen ever dreamed that their schemes held any objective validity such as would assist the astronomer and the physicist in understanding and classifying material phenomena. It is not certain that they will; but the possibility is definite. Apart from this, the whole development of relativity is an extraordinary triumph for pure mathematics. Had Einstein not found his entire calculus ready to hand, owing to the purely mathematical work of Christoffel, Riemann, and others, it seems certain that the development of generalised relativity would have been much slower. It is a pleasure to be able to acknowledge this indebtedness of physics and astronomy to pure mathematics.

Relativity is the revolutionary movement in physics which has caught the public eye, perhaps because it deals with familiar conceptions in a manner which for the most part is found pleasantly incomprehensible. But it is only one of a number of revolutionary changes of comparable magnitude. Among these we have to place the advent of the quantum, the significance of which I hope we shall thoroughly discuss early next week. The various consequences of the electronic structure of matter are still unfolding themselves to us, and are increasing our insight into the most varied phenomena at a rate which must have appeared incredible only a few decades ago.

The enormous and far-reaching importance of the discoveries being made at Cambridge by Sir Ernest Rutherford cannot be over-emphasised. These epoch-making discoveries relate to the structure and properties of the nuclei of atoms. At the present time we have, I think, to accept it as a fact that the atoms consist of a positively charged nucleus of minute size, surrounded at a fairly respectful distance by the number of electrons requisite to maintain the structure electrically neutral. The nucleus contains all but about one-two-thousandth part of the mass of the atom, and its electric charge is numerically equal to that of the negative electron multiplied by what is called the atomic number of the atom, the atomic number being the number which is obtained when the chemical elements are enumerated in the order of the atomic weights; thus hydrogen = 1, helium = 2, lithium = 3, and so on. Consequently the number of external electrons in the atom is also equal to the atomic number. The evidence, derived from many distinct and dissimilar lines of enquiry, which makes it necessary to accept the foregoing statements as facts, will be familiar to members of this Section of the British Association, which has continually been in the forefront of contemporary advances in physical science. But I would remind you in passing that one of the important pieces of evidence was supplied by Prof. Barkla's researches on the scattering of X-rays by light atoms.

The diameters of the nuclei of the atoms are comparable with one-millionth of one-millionth part of a centimetre, and the problem of finding what lies within the interior of such structure seems at first sight almost hopeless. It is to this problem which Rutherford has addressed himself by the direct method of bombarding the nuclei of the different atoms with the equally minute high-velocity helium nuclei (alpha-particles) given off by radioactive substances, and examining the tracks of any other particles which may be generated as a result of the impact. A careful and critical examination of the results shows that hydrogen nuclei are thus expelled from the nuclei of a number of atoms such as nitrogen and phosphorus. On the other hand, oxygen and carbon do not eject hydrogen under these circumstances, although there is evidence in the case of oxygen and nitrogen of the expulsion of other sub-nuclei whose precise structure is a matter for further inquiry.

The artificial transmutation of the chemical elements is thus an established fact. The natural transmutation has, of course, been familiar for some years to students of radioactivity. The philosopher's stone, one of the alleged chimeras of the mediæval alchemists, is thus within our reach. But this is only part of the story. It appears that in some cases the kinetic energy of the ejected fragments is greater than that of the bombarding particles. This means that these bombardmens are able to release the energy which is stored in the nuclei of atoms. Now, we know from the amount of heat liberated in radioactive disintegration that the amount of energy stored in the nuclei is of a higher order of magnitude altogether, some millions of times greater, in fact, than that generated by any chemical reaction such as the combustion of coal. In this comparison, of course, it is the amount of energy per unit mass of reacting or disintegrating matter which is under consideration. The amounts of energy which have thus far been released by artificial disintegration of the nuclei are in themselves small, but they are enormous in comparison with the minute amounts of matter affected. If these effects can be sufficiently intensified, there appear to be two possibilities. Either they will prove

uncontrollable, which would presumably spell the end of all things, or they will not. (To reassure the nervous I would, however, interpolate the comforting thought that this planet has held considerable quantities of radioactive matter for a very long time without anything very serious happening so far as we know.) If they can be both intensified and controlled, then we shall have at our disposal an almost illimitable supply of power which will entirely transcend anything hitherto known. It is too early yet to say whether the necessary conditions are capable of being realised in practice, but I see no elements in the problem which would justify us in denying the possibility of this. It may be that we are at the *beginning of a new age, which will be referred to* as the age of sub-atomic power. We cannot say; time alone will tell.

Thermionic Emission.

With your permission, I will now descend a little way from the summit of Mount Olympus, and devote the rest of my address to a sober review of the present state of some of the questions *with which my own thoughts have been more par*ticularly occupied. At the Manchester meeting of the Association in 1915, I had the privilege of opening a discussion on thermionic emission—that is to say, the emission of electrons and ions by incandescent bodies. I recall that the opinion was expressed by some of the speakers that these phenomena had a chemical origin. That view, I venture to think, is one which would find very few supporters now. It is not that any new body of fact has arisen in the meantime. The important facts were all established before that time, but they were insufficiently appreciated, and their decisiveness was inadequately realised.

It may be worth while to revert for a moment to the issues in that controversy, already moribund in 1915, because it has been closely paralleled by similar controversies relating to two other groups of phenomena—namely, photoelectric emission and contact electromotive force—which, as we shall see, are intimately connected with thermionic emission. The issue was not as to whether thermionic emission may be looked upon simply as a type of chemical reaction. Such an issue would have been largely a matter of nomenclature. Thermionic electron emission has many features in common with a typical reversible chemical reaction such as the dissociation of calcium carbonate into lime and carbon dioxide. There is a good deal to be said for the point of view which regards thermionic emission as an example of the simplest kind of reversible chemical action, namely, that kind which consists in the dissociation of a neutral atom into a positive residue and a negative electron, inasmuch as we know that the negative electron is one of the really fundamental elements out of which matter is built up. The issue in debate was, however, of a different character. It was suggested that the phenomenon was not primarily an emission of electrons from the metallic or other source, but was a *secondary phenomenon, a kind of by*-product of an action which was primarily a chemical reaction between the source of electrons and some other material substance such as the highly attenuated gaseous atmosphere which surrounded it. This suggestion carried with it either implicitly or explicitly the view that the source of power behind the emission was not the thermal energy of the source, but was the chemical energy of the postulated reactions.

This type of view has never had any success in elucidating the phenomena, and I do not feel it necessary at this date to weary you with a recital of the facts which run entirely counter to it, and, in fact, definitely exclude it as a possibility They have been set forth at length elsewhere on more than one occasion. I shall take it to be established that the phenomenon is physical in its origin and reversible in its operation.

Establishing the primary character of the phenomenon does not, however, determine its nature or its immediate cause. Originally I regarded it as simply kinetic, a manifestation of the fact that as the temperature rose the kinetic energy of some of the electrons would begin to exceed the work of the forces by which they are attracted to the parent substance. With this statement, there is, I think, no room for anyone to quarrel, but it is permissible to inquire how the escaping electrons obtain the necessary energy. *One answer is that the electrons have it already* in the interior of the substance by virtue of their energy of thermal agitation. But thermal agitations now appear less simple than they used to be regarded, and in any event they do not exhaust the possibilities.

We know that when light of short enough wavelength falls on matter it causes the ejection of electrons from it—the so-called photo-electric effect. Since the formula for the radiation emitted by a body at any given temperature contains every wave-length without limitation, there must be some emission of electrons from an incandescent body as the result of the photoelectric effect of its own luminosity. Two questions obviously put themselves. Will this photoelectric emission caused by the whole spectrum of the hot body vary as the temperature of the incandescent body is raised in the way which is known to characterise thermionic emission? A straightforward thermodynamic caluculation shows that this is to be expected from the theoretical standpoint, and the anticipation has been confirmed by the experiments of Prof. W. Wilson. Thus the autophotoelectric emission has the correct behaviour to account for the thermionic emission. The other question is: Is it large enough? This is a question of fact. I have considered the data very carefully. There is a little uncertainty in some of the items, but when every allowance is made there seems no escape from the conclusion that the photoelectric effect of the whole spectrum is far too small to account for thermionic emission.

This question is an important one, apart from the particular case of thermionic emission. The same dilemma is met with when we seek for the actual *modus operandi* of evaporation, chemical action, and a number of other phenomena. These, so far as we know, might be fundamentally either kinetic or photochemical or a mixture of both. In *my judgment the last alternative is the most prob*able. (I am using the term photochemical here in the wide sense of an effect of light in changing the composition of matter, whether the parts affected are atoms, groups of atoms, ions, or electrons.) For example, the approximation about boiling points known as Trouton's rule is a fairly

obvious deduction from the photochemical standpoint. The photochemical point of view has recently been put very strongly by Perrin, who would make it the entire *motif* of all chemical reaction, as well as of radioactivity and changes of state. In view of the rather minor part it seems to play in thermionic emission, where one would *a priori* have expected light to be especially effective, this is probably claiming too much for it, but the chemical evidence contains one item which is certainly difficult to comprehend from the kinetic standpoint. The speed of chemical decomposition of certain gases is independent of their volume, showing that the decomposition is not due to molecular collisions. The speed does, however, increase very rapidly with rising temperature What the increased temperature can do except increase the number and intensity of the collisions, factors which the independence of volume at constant temperature show to be without effect, and increase the amount of radiation received by the molecules, is not too obvious. It seems, however, that, according to calculations by Langmuir (*Journ. Am. Chem. Soc.*, 1920, xlii., 2190), the radiation theory does not get us out of this difficulty; for, just as in the ordinary photoelectric case, there is nothing like enough radiation to account for the observed effects. It seems that in the case of these mono-molecular reactions the phenomena cannot be accounted for either by simple collisions, or by radiation, or by a mixture of both, and it is necessary to fall back on the internal structure of the decomposing molecule. This is complex enough to afford material sufficient to cover the possibilities; but, from the standpoint of the temperature energy relations of its parts, it cannot at present be regarded as much more than a field for speculation.

Contact Electricity.

A controversy about the nature of the contact potential difference between two metals, similar to that to which I have referred in connection with thermionic emission, has existed for over a century. In 1792 Volta wrote: "The metals . . . can by themselves, and of their own proper virtue, excite and dislodge the electric fluid from its state of rest." The contrary position that the electrical manifestations are inseparably connected with chemical action was developed a few years later by Fabroni. Since that time electrical investigators have been fairly evenly divided between these two opposing camps. Among the supporters of the intrinsic or contact view of the type of Volta, we may recall Davy, Helmholtz, and Kelvin. On the other side we have to place Maxwell, Lodge, and Ostwald. In 1862 we find Lord Kelvin ("Papers on Electrostatics and Magnetism," p. 318) writing: "For nearly two years I have felt quite sure that the proper explanation of voltaic action in the common voltaic arrangement is very near Volta's, which fell into discredit because Volta or his followers neglected the principle of the conservation of force." On the other hand, in 1896, we find Ostwald (*Elektochemie, Ihre Geschichte und Lehre*, Leipzig, 1896, p. 65), referring to Volta's views as the origin of the most far-reaching error in electrochemistry, which the greatest part of the scientific work in that domain has been occupied in fighting almost ever since. These are cited merely as representative specimens of the opinions of the protagonists.

Now, there is a close connection between thermionic emission and contact potential difference, and I believe that a study of thermionic emission is going to settle this little dispute. In fact, I rather think it has already settled it, but before going into that matter I would like to explain how it is that there is a connection between thermionic emission and contact potential difference, and what the nature of that connection is.

Imagine a vacuous enclosure, either impervious to heat or maintained at a constant temperature. Let the enclosure contain two different electron-emitting bodies, A and B. Let one of these, say A, have the power of emitting electrons faster than the other, B. Since they are each receiving as well as emitting electrons, A will acquire a positive and B a negative charge under these circumstances. Owing to these opposite charges, A and B will now attract each other, and useful work can be obtained by letting them come in contact. After the charges on A and B have been discharged by bringing them in contact, let the bodies be quickly separated and moved to their original positions. This need involve no expenditure of work, as the charges arising from the electron emission will not have had time to develop. After the charges have had time to develop the bodies can again be permitted to move together under their mutual attraction, and so the cycle can be continued an indefinite number of times. In this way we have succeeded in imagining a device which will convert all the heat energy from a source at a uniform temperature into useful work.

Now, the existence of such a device would contravene the second law of thermodynamics. We are, therefore, compelled either to deny the principles of thermodynamics or to admit that there is some fallacy as to the pretended facts in the foregoing argument. We do not need to hesitate between these alternatives, and we need only look to see how the alleged behaviour of A and B will need to be modified in order that no useful work may appear. There are two alternatives. Either A and B necessarily emit equal numbers (which may include the particular value zero) of electrons at all temperatures, or the charges which develop owing to the unequal rate of emission are not discharged, even to the slightest degree, when the two bodies are placed in contact.

The first alternative is definitely excluded by the experimental evidence, so I shall proceed to interpret the second. It means that bodies have natural states of electrification whereby they become charged to definite potential differences whose magnitudes are independent of their relative positions. There is an intrinsic potential difference between A and B which is the same, at a given temperature, whether they are at a distance apart or in contact. In the words of Volta, which I have already quoted, "the metals can by themselves, and of their own proper virtue, excite and dislodge the electric fluid from its state of rest."

Admitting that the intrinsic potentials exist, a straightforward calculation shows that they are intimately connected with the magnitudes of the thermionic emission at a given temperature. The relation, is, in fact, governed by the following equation: If A and B denote the saturation thermionic currents per unit area of the bodies A and

B respectively, and V is the contact potential difference between them at the absolute temperature T, then $V = \frac{kT}{e} \log \frac{A}{B}$ where k is the gas constant calculated for a single molecule (Boltzmann's constant), and e is the electronic charge.

I have recently, with the help of Mr. F. S. Robertson, obtained a good deal of new information on this question from the experimental side. We have made measurements of the contact potential difference between heated filaments and a surrounding metallic cylinder, both under the high-vacuum and gas-free conditions which are now attainable in such apparatus, and also when small known pressures of pure hydrogen are present. As is well kown, both contact potentials and thermionic emission are very susceptible to minute traces of gas, but we find that under the best conditions as to freedom from gas there is a contact potential of the order of one volt between a pure tungsten filament and a thoriated filament. We have also been able to measure the thermionic emissions from the filaments at the same time, and we find that the contact potential calculated from them with the help of the foregoing equation is within 20 per cent of the measured value. Considering the experimental difficulties, this is a very substantial agreement. Whilst the evidence is not yet as complete as I hope to make it, it goes a long way towards disproving the chemical view of the origin of contact potential difference.

From what has been said you will realise that the connection between contact potentials and thermionic emissions is a very close one. I would, however, like to spend a moment in developing it from another angle. To account for the facts of thermionic emission it is necessary to assume that the potential energy of an electron in the the space just outside the emitter is greater than that inside by a definite amount, which we may call w. The existence of this w, which measures the work done when an electron escapes from the emitter, is required by the electron-atomic structure of matter and of electricity. Its value can be deduced from the temperature variation of thermionic emission, and, more directly, from the latent heats absorbed or generated when electrons flow out of or into matter. These three methods give values of w which, allowing for the somewhat considerable experimental difficulties, are in fair agreement for any particular emitter. The data also show that in general different substances have different values of w. This being so, it is clear that when uncharged bodies are placed in contact the potential energies of the electrons in one will in general be different from those of the electrons in the other. If, as in the case of the metals, the electrons are able to move freely, they will so move until an electric field is set up which equilibrates this difference of potential energy. There will thus be an intrinsic or contact difference of potential between metals which is equivato the difference in the values of w and is equal to the difference in w divided by the electronic charge. (This statement is only approximately true. In order to condense the argument, certain small effects connected with the Peltier effect at the junction between the metals have been left out of consideration).

Photoelectric Action.

We have seen that there is a connection on broad lines between thermionic emission and both contact potentials on the one hand, and photoelectric emission on the other. The three groups of phenomena are also related in detail and to an extent which up to the present has not been completely explored. In order to understand the present position, let us review briefly some of the laws of photoelectric action as they have revealed themselves by experiments on the electrons emitted from metals when illuminated by visible and ultra-violet light.

Perhaps the most striking feature of photoelectric action is the existence of what has been called the threshold frequency. For each metal whose surface is in a definite state there is a definite frequency n_0, which may be said to determine the entire photoelectric behaviour of the metal. The basic property of the threshold frequency n_0 is this: When the metal is illuminated by light of frequency less than n_0 no electrons are emitted, no matter how intense the light may be. On the other hand, illumination by the most feeble light of frequency greater than n_0 causes some emission. The frequency n_0 signalises a sharp and absolute discontinuity in the phenomena.

Now let us inquire as to the kinetic energy of the electrons which are emitted by a metal when illuminated by monochromatic light of frequency, let us say, n. Owing to the fact that the emitted electrons may originate from different depths in the metal, and may undergo collisions at irregular intervals, it is only the maximum kinetic energy of those which escape which we should expect to exhibit simple properties. As a matter of fact, it is found that the maximum kinetic energy is equal to the difference between the actual frequency n and the threshold frequency n_0 multiplied by Planck's constant h. In mathematical symbols, if v is the velocity of the fastest emitted electron, m its mass, e its charge, and V the opposing potential required to bring it to rest,

$$eV = \tfrac{1}{2}mv^2 = h(n - n_0).$$

From this equation we see that the threshold frequency has another property. It is evidently that frequency for which kinetic energy and stopping potential fall to zero. This suggests strongly, I think, that the reason the electron emission ceases at n_0 is that the electrons are not able to get enough energy from the light to escape from the metal, and not that they are unable to get any energy from the light.

The threshold frequencies have another simple property. If we measure the threshold frequencies for any pair of metals, and at the same time we measure the contact difference of potential K between them, we find that K is equal to the difference between their threshold frequencies multiplied by this same constant h divided by the electronic charge e.

These results, as well as others which I have not time to enumerate, admit of a very simple interpretation if we assume that when illuminated by light of frequency n the electrons individually acquire an amount of energy hn. We have seen that in order to account for thermionic phenomena it is necessary to assume that the electrons have to do a certain amount of work w to get away from the emitter. There is no reason to suppose

that photoelectrically emitted electrons can avoid this necessity. Let us suppose that his work is also definite for the photoelectric electrons and let us denote its value by hn_0. Then no electron will be able to escape from the metal until it is able to acquire an amount of energy at least equal to hn_0 from the light—that is to say, under the suppositions made—until n becomes at least as great as n_0. Thus n_0 will be identical with the frequency which we have called the threshold frequency, and the maximum energy of any electron after escaping will be $h\ (n-n_0)$.

The relation between threshold frequencies and contact potential difference raises another issue. We have seen that the contact potential difference beween two metals must be very nearly equal to the difference between the amounts of work w for the electrons to get away from the two metals by thermionic action, divided by the electronic charge e. The photoelectric experiments show that the contact electromotive force is also nearly equal to the differences of the threshold frequencies multiplied by h/e. It follows that the photoelectric work hn_0 must be equal to the thermionic work w to the same degree of accuracy. We have to except here a possible constant difference between the two. I do not see, however, how any value other than zero for such a constant could be given a rational interpretation, as it would have to be the same for all substances and frequencies. The photoelectric and thermionic works are known to agree to within about one volt. To decide how far they are identical needs better experimental evidence than we have at present. The indirect evidence for their substantial identity (that is to say, within the limits of accuracy referred to above) is stronger at the moment than the direct evidence.

I do not think that the complete identity of the thermionic work w and the photoelectric hn_0 is a matter which can be inferred *a priori*. What we should expect depends to a considerable extent on the condition of the electrons in the interior of metals. We cannot pretend to any real knowledge of this at the present; the various current theories are mere guesswork. Unless the electrons which escape all have the same energy when inside the metal we should expect the thermionic value to be an average taken over those which get out. The photoelectric value, on the other hand, should be the minimum pertaining to those internal electrons which have most energy. The apparent sharpness of the threshold frequency is also surprising from some points of view. There seems to be scope for a fuller experimental examination of these questions.

I have spoken of the threshold frequency as though it were a perfectly definite quantity. No doubt it is when the condition of the body is or can be definitely specified, but it is extraordinarily sensitive to minute changes in the conditions of the surface, such as may be caused, for example, by the presence of extremely attenuated films of foreign matter. For this reason we should accept with a certain degree of reserve statements which appear from time to time that photoelectric action is some parasitic phenomenon, inasmuch as it can be made to disappear by improvement of vacuum or other change in the conditions. What has generally happened in these investigations is that something has been done to the illuminated surface which has raised its threshold frequency above that of the shortest wave-length in the light employed in the test. Unless they are accompanied by specific information about the changes which have taken place in the threshold frequency, such statements are of little value at the present stage of development of this subject.

Interesting calculations have been made by Frenkel which bring surface tension into close connection with the thermionic work w. Broadly speaking, there can be little doubt that a connection of this nature exists, but whether the relation is as simple as that given by the calculations is open to doubt. It should be possible to answer this question definitely when we have more precise information about the disposition of the electrons in atoms such as the continuous progress in X-ray investigation seems to promise.

Light and X-Rays.

One of the great achievements of experimental physics in recent years has been the demonstration of the essential unity of X-rays and ordinary light. X-rays have been shown to be merely light of particularly high frequency or short wave-length, the distinction between the two being one of degree rather than of kind. The foundations of our knowledge of X-ray phenomena were laid by Barkla, but the discovery and development of the crystal diffraction methods by v. Laue, the Braggs, Mosley, Duane, and de Broglie have established their relations with ordinary light so clearly that he who runs may read their substantial identity. The actual gap in the spectrum of the known radiations between light and X-rays is also rapidly disappearing. The longest stride into the region beyond the ultra-violet was made by Lyman with the vacuum grating spectroscope which he developed. For a short time Prof. Bazzoni and I held the record in this direction with our determination of the short wave limit of the helium spectrum, which is in the neighbourhood of 450 Ångstrom units. More recently this has been passed by Millikan, who has mapped a number of lines extending to about 200 Ångstrom units—that is to say, more than four octaves above the violet limit of the visible spectrum. I am not sure what is the longest X-ray which has been measured, but I find a record of a Zinc L-ray by Friman (*Phil. Mag.*, 1916, xxxii., 494) of a wave-length of 12·346 Ångstrom units. There is thus at most a matter of about four octaves still to be explored. In approaching this unknown region from the violet end, the most characteristic property of the radiaitons appears to be their intense absorption by practically every kind of matter. This result is not very surprising from the quantum standpoint. The quantum of these radiations is in excess of that which corresponds to the ionising potential of every known molecule, but it is of the same order of magnitude. Furthermore, it is large enough to reach not only the most superficial, but also a number of the deeper-seated electrons of the atoms. There is evidence, both theoretical and experimental, that the photoelectric absorption of radiation is most intense when its quantum exceeds the minimum quantum necessary to eject the absorbing electron but does not exceed it too much. In the simplest theoretical case the absorption is zero for radiations whose frequencies lie below the minimum quantum, rises

to a maximum for a frequency comparable with the minimum, and falls off to zero again at infinite frequency. This case has not been realised in practice, but, broadly judged, the experimental data are in harmony with it. On these general grounds we should expect intense absorption by all kinds of matter for the radiation between the ultra-violet and the X-ray region.

The closeness of the similarity in the properties of X-rays and light is, I think, even yet inadequately realised. It is not merely a similarity along broad lines, but it extends to a remarkable degree of detail. It is perhaps most conspicuous in the domains of photoelectric action and of the inverse phenomenon of the excitation of radiation or spectral lines by electron impacts. Whilst there may still be room for doubt as to the precise interpretation of some of the experimental data, the impression I have formed is that each important advance tends to unify rather than to disintegrate these two imporrant groups of phenomena.

THE STRUCTURAL RELATION OF ISOQUINOLINE AND PHENANTHRENE ALKALOIDS.

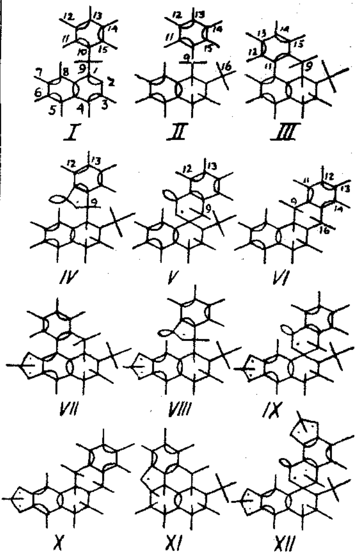
By INGO W. D. HACKH.

An interesting structural relation among alkaloids containing the isoquinoline nucleus was revealed by working with their structure symbols (*Canadian Chem. Journ.*, 1918, ii., 135; *Science*, 1918, xlviii., 333; *Chem. Eng.*, 1918, xxvi., 377; Chemical News, cxviii., 289, and cxxi., 85; *Chem. Age* (London), iii., 392; *Journ. Am. Pharm. Assoc.*, 1920, ix., 392). Comparing the structural formulas of morphine (Pschorr), berberine (Parkin), papaverine (Goldschmidt), glaucine (Fischer), narcotine (Perkin and Robinson), corydaline (Dobbie and Lauder), dicentrine (Gadamer), protopine and cryptopine (Perkin), &c., as usually given in chemical literature will not indicate any relationship in structure, in fact, these alkaloids appear to belong to entirely different groups. If these structural formulas, or the corresponding structure symbols, however, are turned and shifted so as to bring the isoquinoline nucleus into the same relative position; it is possible to trace a structural relationship which genetically connects all these alkaloids.

Thus the unsaturated tricyclic system I or 1-benzyl-isoquinoline may be used as the starting-point for the structural derivation of a great number of alkaloids. Paperoline is the 6.7.12.13-tetrahydroxy derivative of I, and papaverine is the 6.7.12.13-tetramethhoxy derivative of I.

By partial saturation and methylation the ring-system II or 1.3.4-trihydro-N-Methyl-1-benzyl-iso quinoline is derived. This is the parent compound of laudanosine which is the 6.7.12.13-tetramethoxy derivative of II.

The hydrocarbon II contains a benzene and isoquinoline nucleus, and is thus a tricyclic system from which in four different ways an additional ring formation tetracyclic systems are derived; each of them characteristic of certain alkaloids. Thus the fourth ring can be formed by direct connection of the eights with the eleventh carbon atom (III), by a lactone formation between the ninth and eleventh carbon atom (IV) giving a pentatomic ring, by lactone formation between the first and eleventh carbon atom (V) giving a hexatomic ring, or finally by connecting the fifteenth carbon atom with the N-methyl carbon atom (VI).

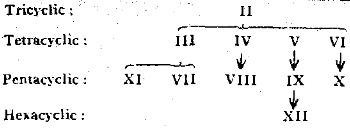


The tetracyclic system III is derived from II by connecting the eighth with the eleventh carbon atom, thereby forming a phenanthrene nucleus. Corytuberine is the 6.7-dimethoxy-12.13-dihydroxy derivative of III—corydine is the 6.7.12-trimethoxy-13-hydroxy derivative of III—and glaucine is the 6.7.12.13-tetramethoxy derivative of III.

At present there are no alkaloids known which are the methoxy or hydroxy derivatives of the tetracyclic system IV or V, but, as these are the stepping stones to the pentacyclic system VIII and IX, and the hexacyclic system XII, it appears that their existence is possible and the prediction of their occurrence in plants is plausible.

The tetracyclic system VI is derived from II by connecting the N-methyl carbon atom with the fifteenth carbon atom. Corydaline is the 9-methyl-12.13-dimethoxy derivative of VI.

From the four tetracyclic systems, III, IV, V, and VI, there are five pentacyclic systems derived by the formation of an additional penatomic ring which is usually produced by attaching a methylene dipxy group ($-O.CH_2-O-$) to the sixth and seventh carbon atoms. The relation of these systems is shown by the diagram:



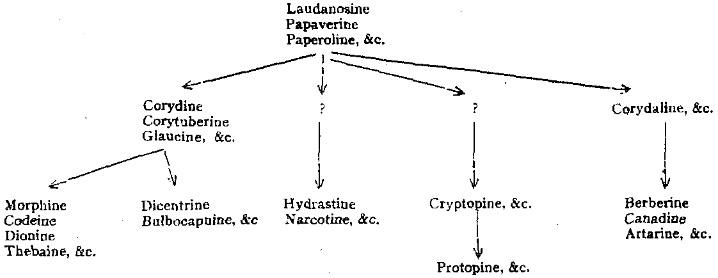
The pentacyclic system VII has the methylene-dioxy group in the 6.7-position, and its 12.13-dimethoxy derivative is dicentrine—the 12-hydoxy-13-methoxy derivative is bulbocapnine.

The pentacyclic system VIII is represented in hydrastine, the 12.13-dimethoxy derivative, and narcotine, the 8.12.13-trimethoxy derivative. Cryptopine is the compound given in IX, and berberine is the 9-hydroxy-12.13-dimethoxy derivative of X.

The fifth pentatomic ring may also be formed by connecting the seventh and twelfth carbon atom of III by an oxygen atom, thus the pentacyclic system XI results. If partially saturated, this forms the parent compound of the morphine alkaloids. Thus morphine is the 6.13-dihydroxy derivative of XI, codeine the 6-hydroxy-13-methoxy derivative, dionine the 6-hydroxy-13-ethoxy derivative, and thebaine the 6.13-dimethoxy derivative of XI.

Only one instance is on record in which the structure of an isoquinoline alkaloid contains six rings, as shown in XII for protopine. This hexacyclic system is derived from IX by attaching the second methylene dioxy group to the twelfth and thirteenth carbon atom.

It is of interest to note that substitution practically always takes place at the 6.7- and 12.13-position, whether it be by the hydroxy, methoxy, ethoxy, or the methylene-dioxy group. It is also significant to note that the apparent genetic relation among these alkaloids, although the respective structural formulas have been determined at different times by different investigators. In this connection it appears likewise that the morphine formula, as given by Pschorr, is the correct one, and more plausible than those given by Freund and others. These structural relations enable the following classification of the alkaloids:



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THE ELECTRIC FURNACE SPECTRUM OF SCANDIUM.*

By ARTHUR S. KING.

SCANDIUM occurs in small amounts in a number of the rare-earth minerals, but its extraction in a fair degree of purity is an exceedingly difficult matter, and, as its separation has not been stimullated by any commercial application, the substance is extremely scarce. The late Sir William Crooks (*Philosophical Transactions*, A, 1909, ccix., 15) described his examination of a large number of minerals in a search for those containing scandium. Wiikite, found in Finland, proved to contain over 1 per cent of scandium oxide (scandia), and was used by him to furnish pure scandia. The final difficulty in the tedious process of separation was the elimination of the closely related elements yttrium and ytterbium.

The spectrum of scandium is especially interesting on account of the peculiar intensity relations, to be discussed presently, among the scandium lines in the solar spectrum. An examination of the behaviour of the lines at various temperatures of the electric furnace was therefore desirable, in order to determine the part which temperature may play in bringing about the peculiarities observed.

Through the good offices of Prof. Fowler, I have been able recently to obtain a sufficient amount of highly purified scandia to carry out the examination of the furnace spectrum. This scandia was prepared by Sir William Crookes. His former assistant, Mr. J. H. Gardiner, very kindly placed the material at my disposal through Prof. Fowler.

In the earlier solar investigations in which the spot spectrum was studied, it was noted that certain lines intensified in the spot coincided with lines in the scandium arc, while other strong arc lines were absent in the spot though present in the solar spectrum and prominent in the chromosphere. Fowler (*ibid.*, A., 1909, ccix., 47) explained this phenomenon by producing, besides

* Abridgement of a Paper on the Electric Furnace Spectrum of Scandium. Contribution from the Mount Wilson Observatory, No. 211.

the regular arc spectrum, the spectrum of the arc in hydrogen, which approaches that of the spark, and the spectrum of the flame of the arc, in which certain lines are given a high intensity. His results showed clearly that the lines prominent in the spot spectrum are those given by the flame of the arc, and probably result from a reduced temperature in the spot, while the scandium lines missing from the spot spectrum are enhanced lines, though present often with considerable intensity in the arc. The occurrence of three distinct types, enhanced, arc, and flame lines, in the scandium arc is a feature shown by some other elements, notably titanium, the low-temperature lines of which have been selected by the furnace (*Mt. Wilson Contr.*, No. 76; *Astrophys. Journ.*, 1914, xxxix., 139), while many lines prominent in the arc are much enhanced in the spark.

Experimental Method.

The tube-resistance furnace was operated as usual, the chamber being pumped out to a few millimetres' pressure. To avoid scattering of the scandia in the tube, the powder was put in a small combustion boat of graphite, which was placed at the middle of the furnace-tube. The image of the space above this boat was focused on the slit of the spectrograph. The scandia fused in the boat, entering to some extent into the graphite as if a carbide were formed. The fused residue was a shining black when removed from the tube, but after exposure to the air for some time turned to a grey-brown powder, presumably from the reabsorption of oxygen.

The spectrograms were made with a 15ft. concave grating spectrograph, the second order with a dispersion of 1 mm. = 1·86 A being used for the ultra-violet, and the first order for the region from λ3800 into the red.

Conclusion.

The varying response of spectrum lines to temperature change, observed in the study at different temperatures of the furnace spectrum of scandium, has concerned itself especially with the conditions of appearance and development of the three main types—enhanced, arc, and low-temperature lines—which make up the spectrum. The scandium enhanced lines, as regards degree of excitation required, stand between the enhanced lines of titanium and those of the type of H and K of calcium. For the lines appearing in the arc spectrum the regular temperature classification is carried out. The group of arc lines given by the arc flame consists of prominent low-temperature lines, but, since many lines strong in the furnace are relatively weak in all parts of the arc, additional data on this type of line are supplied by the furnace spectrum.

The explanation advanced by Fowler as to the relative strength of the different types of scandium lines in the solar and sun-spot spectra is fully confirmed by their varying response to the furnace excitation. The strong low-temperature lines, faint or lacking in the disc, are distinctly brought out in the spot, and, especially in the red, show high sensitiveness to the magnetic field. A comparison of the Zeeman effect for scandium in the laboratory with that shown in spot spectra and a fuller listing of the scandium lines present in the sun are needed to give this element its due place among those on which solar studies are based.—*Astrophysical Journal*, July, 1921.

PROCEEDINGS OF SOCIETIES.

INSTITUTE OF METALS.

Birmingham Meeting, September 21-22, 1921.

"*The Properties of Some Nickel-Aluminium-Copper Alloys.*" By Prof. A. A. READ, D.Met., Member (Cardiff), and R. H. GREAVES, M.Sc., Member (Woolwich).

In some of the copper-rich nickel-aluminium-copper alloys the alpha solution will retain much more nickel and aluminium at 900° C. than at ordinary temperatures. Alloys typical of the region comprised between the limits of composition of the alpha solution at 900° and at ordinary temperatures have been examined. These alloys while relatively soft on quenching from 900°, are hardened by slow cooling from that temperature, or by reheating to lower temperatures. This change is the result of the appearance of a new constituent (probably a nickel-aluminium-copper solid solution), the separation of which is accompanied by changes in the density and electrical conductivity of the alloy in addition to its effect on tensile, hardness, notched bar, and other tests. The separation of this special constituent takes place somewhat slowly, so that chill-cast alloys and hot-rolled rods of small section consist almost wholly of the alpha constituent. The cold-rolled rod, obtained by hot-rolling, followed by a few passes in the cold, thus consists almost wholly of the alpha constituent. On annealing the cold-rolled alloys, softening proceeds very slowly up to 500°, at which temperature precipitation of the nickel-aluminium rich constituent begins to take place at an appreciable rate, with the result that with some compositions a progressive increase of hardness is obtained by holding the alloy at 500° C. If the separation is sufficient, this may more than counterbalance the previous softening, giving an alloy of high elastic limit and tensile strength, and good elongation (*e.g.*, a maximum load of over 50 tons per square inch, with an elongation of 20 per cent). The rate of cooling from a temperature above that at which the alpha solution begins to deposit the special constituent has a great influence on the mechanical properties of the heat-treated alloys. The hardest product is, however, obtained by reheating the quenched alloy for some time at 600° to 700° C. (say two hours at 600°, or half-an-hour at 700°). The alloys so treated generally give better properties than are obtained by any uniform rate of slow cooling (*e.g.*, yield point over 20 tons per square inch, maximum load over 40 tons per square inch, elongation about 15 to 25 per cent). The heat-treated alloys show considerable endurance under alternating stresses above their true fatigue limit, the determination of which involves a number of prolonged tests.

"*The Effect of Increasing Proportions of Lead upon the Properties of Admiralty Gun-metal, with an Appendix dealing with the Effect of Lead on Gun-metal containing Copper 85 per cent, Tin 5 per cent, Zinc 10 per cent.*" By R. T. ROLFE, F.I.C., Member (Bedford).

The effects of lead upon Admiralty gun-metal has been studied by the production of synthetic

alloys containing gradually increasing proportions of lead up to 1·68 per cent, subject to control as regards compositions, casting temperatures, and general conditions. Sand and chill-castings were produced, while a duplicate set of determinations were made on re-melts of the original alloys, thus checking the results from these and affording information on the variations in composition and properties caused by re-melting. In sand-cast gun-metal, lead gradually increases the strength, ductility, and softness of the alloy up to about 1·5 per cent of lead, but above this proportion causes a decrease in all three. Maximum repeated-impact resistance is obtained with 1 per cent of lead, falling away when this figure is exceeded. Lead does not affect the soundness, and is microscopically readily detectable on either the plain, polished, or etched surfaces. In chill-cast gun-metal, these effects are rather marked. The effect on the hardness parallels that of the sand-cast metal, with a change-point at about 1·5 per cent of lead, but associated with a minimum rather than a maximum strength figure. Increasing lead proportionately decreases the ductility and also the impact-figure of the metal twice melted, that melted once giving more irregular results. Lead does not affect the soundness, and is microscopically readily detectable on the plain polished surface. The influence of lead on liquation, machinability, corrosion, and behaviour for bearing purposes is also discussed, and it is suggested that in sand-cast gun-metal, the proportion of lead permitted by the Admiralty specification might with advantage be increased from 0·5 to 1 per cent. An Appendix deals with the influence of increasing proportions of lead upon the properties of gun-metal containing copper 85 per cent, tin 5 per cent, zinc 10 per cent.

"*The Density of the Zinc-Copper Alloys.*" By T. G. Bamford, M.Sc., Member (Birmingham).

The density of alloys, the author points out, is important both from a theoretical and a practical standpoint. When the correct density is known, it is possible to determine whether casting conditions have been satisfactory. Hitherto no trustworthy determinations of the densities of the copper-zinc series have been available. The author, after reviewing earlier work, records experiments conducted with alloys made from pure metals, and cast in sand- and chill-moulds respectively. The results indicate that there is a contraction in volume (*i.e.*, increase of density) due to alloying with mixtures containing more than 25 per cent of copper; and that the density of the sand cast (or slowly cooled) alloys is generally less than is the case with the chill castings, but that at points where the liquidus and solidus coincide on the constitutional diagram, chill castings and sand castings give the same values. These results afford striking confirmation of the data published by Turner and Murray on the volume changes of the copper-zinc alloys. The expansion recorded by these observers with alloys containing less than 30 per cent of copper is confirmed, and is shown to be connected with a new form of porosity different from ordinary unsoundness.

"*The Extrusion Defect.*" By R. Genders, M.B.E., B.Met., Member (Woolwich).

Experiments have been carried out with the object of devising a method of extrusion which would avoid the formation of the defect (known by the misleading term "piping") which is commonly found in a certain proportion of centrally extruded rod made from brass and other non-ferrous alloys by the usual hot-extrusion process. The defect is tubular in the interior of the rod, and generally exists in the last portion (up to 25 or 30 per cent) extruded. When a defective rod is broken across, the core frequently breaks at a different point from the outer ring, and projects, and is sometimes quite loose. It has been shown that the defect consists of foreign matter, oxide, and dezincified brass, which constituted the skin of the original billet. Billets extruded to various stages and sectioned axially show the presence of the defect in the shape of a funnel (formed by the turning inwards of the billet skin, which cannot flow along the side of the receiver owing to friction and its lower temperature) by the fact of the ram, and its gradual flow towards the die. The defect can be largely overcome by the use of a ram smaller in diameter than the billet, which causes the outer layer of the billet to remain in the receiver as a thin cylinder, but the method would probably be too wasteful on a large scale. By inverting the process so that the die is pushed through the billet, the mode of flow is altered. There is no relative movement between the billet and receiver, and flow is confined to the region of the die. Experiments on a small scale, using 60-40 brass billets and extruding under conditions comparable with large scale work, have shown this method to be successful in avoiding the "extrusion defect," the skin of the billet being turned over and collected on the face of the die, none entering the aperture of the die until the extrusion is nearly complete, when it emerges on the outside of the rod. The power required is less than with the method at present in use. Rod produced by the method is completely sound. The method is in use in many places for the production of tubes and rod from soft metals, although the plant appears to have been so designed only with a view to mechanical efficiency without any appreciation of possible effect on the quality of the product, and has not so far, to the author's knowledge, been used for hot extrusion of copper alloys. The necessary modifications of the plant would probably be fully justified by the saving of the very large amount of metal which by the present method is extruded only to be ultimately scrapped.

"*The Use of the Scleroscope on Light Specimens of Metals.*" By F. S. Tritton, Member (Teddington).

Some experience in the use of the scleroscope for testing the hardness of small pieces of metal in the laboratory led the author to doubt whether the real hardness values of small samples were obtained, although the usual precautions were taken to support the specimens in an apparently rigid manner. The experiments were undertaken with the view of finding out whether errors existed when using the ordinary methods of support, and, if so, to find some method of support that would eliminate them. Errors were detected, and to reduce them the author selected two materials, respectively

pitch and glucose, for the purpose of supporting the specimens in the scleroscope. The use of pitch requires a special clamp, a new type of which is described. On the other hand, without the use of a clamp, a solution of glucose considerably stiffer than treacle was found to give excellent results, the specimens under test being simply attached by means of the glucose to a hard steel base. In this way there could be readily tested the hardness of specimens having not merely flat but curved surfaces—such as balls or rollers—provided that a recessed support be made to fit the specimens.

"The Constitution and Age-Hardening of the Alloys of Aluminium with Magnesium and Silicon." By D. Hanson, D.Sc., Member, and Marie L. V. Gayler, M.Sc., Member (Teddington).

Constitution of the Alloys.—The constitution of a small portion of the ternary system, aluminium, magnesium, silicon, has been investigated, namely that containing up to 35 per cent magnesium and 11 per cent silicon. The results of thermal curves and microscopic examination prove that in these alloys, magnesium and silicon form a chemical compound having the formula Mg_2Si. This compound and aluminium form a eutectiferous binary system, having a eutectic containing 13 per cent of Mg_2Si, and melting at 590° C. Two ternary systems are formed with silicon and magnesium respectively. The aluminium—Mg_2Si—silicon system possesses a ternary eutectic that melts at 550° C.; the ternary eutectic of the aluminium—Mg_2Si—magnesium system melts at 450° C. The solubility of the compound Mg_2Si in solid aluminium has been determined, and the results show that Mg_2Si is more soluble at high than at low temperatures, 1·6 per cent MgSi being held in solution at 580° C., and little more than 0·5 per cent Mg_2Si at 30° C. Excess of silicon has little effect on the solubility of Mg_2Si, but magnesium reduces the solubility at high temperatures. This difference in the solubility of Mg_2Si in solid aluminium at high and low temperatures is the cause of the age-hardening property of these alloys.

Age-Hardening of the Alloys.—The alloys of this system, after quenching from high temperatures, are relatively soft, but gradually become harder; this age-hardening ceases after a few days. The age-hardening of a series of alloys containing increasing amounts of Mg_2Si rises progressively until the limit of the solubility of Mg_2Si in aluminium at the quenching temperature is reached, beyond which the total increase in hardness remains constant. Hence the increase in hardness produced during the ageing of the alloys is roughly proportional to the amount of Mg_2Si retained in solution by quenching. Confirmation of this view is also obtained from experiments with alloys of aluminium and Mg_2Si with magnesium or silicon.

"The Electrolytic Etching of Metals." By F. Adcock, M.B.E., B.Sc., Member (Ipswich).

As the title implies, electrolytic methods of etching various metals are described with a view to the preparation of useful micro-sections. A solution of citric acid as an electrolyte in the etching bath yielded good results with cupro-nickel (80:20), silver, nickel-silver, and some other metals, and it was noticed that silver and nickel-silver specimens which had been comparatively roughly treated during the polishing process often gave clearer etchings than the specimens which had been polished with great care. Certain specimens of silver showed on etching a cell structure or network which was smaller than, and in some cases independent of, the existing crystal grains. Another electrolyte made by dissolving molybdic acid in excess of ammonia solution gave somewhat similar results, and revealed a subsidiary cell formation or net-work in the beta regions of a beta plus gamma brass containing 6 per cent of aluminium. By making use of such reagents as hydrofluoric acid, chromic acid, and bromine water, both the cores (or dendrites) and the crystal grain boundaries of cast cupro-nickel were disclosed simultaneously. The paper is illustrated with 18 photomicrographs, and concludes with some notes on the etching of gold and platinum.

NOTES.

University of Birmingham.—A Department of Brewing and of Bio-chemistry of Fermentation has been founded at the University of Birmingham. It will be in charge of the Adrian Brown Professor, Mr. Arthur R. Ling, M.Sc., and it has been established for the study of applied bio-chemistry, especially in connection with malting and brewing, and the fermentation industries generally. It deals with agriculture and cognate industries, chemistry and bacteriology as applied to food and drugs, water supply, and the treatment of sewage, &c. There is a degree course, a diploma course, certificate course for brewers and maltsters who are unable to devote the time to study required for the diploma course, and shorter courses of lectures and practical work in the principles of malting and brewing. There are also facilities for training in agricultural chemistry, the chemistry of foods and drugs and of water, and the chemistry of bacteriology and sanitation.

A New Synthetic Resin from Benzylaniline.—Continuing his researches on the synthesis of resinous compounds, starting from the secondary amines in which a compound of the benzyl group figures, Mr. W. Herzog placed 9 grms. of benzylaniline in suspension in a mixture of 10 grms. of 40 per cent formic aldehyde; 20 grms. of water, and 1 cm. of concentrated hydrochloric acid, heated during an hour under a slight reflux. The supernatant solution, which has a strong odour of benzylic aldehyde, is poured out and the resinous matter deposited on the bottom of the vessel, washed several times in hot water, and then dried at about 110° C. Thus a hard, brittle, transparent substance of an amber colour, resembling colophony, is obtained. The yield is about 8·5 per cent. The resin is soluble cold, to the extent of 25 per cent in benzol, as also in trichlorethylene, giving very stable solutions. It is very suitable for making resisting lacquers. In spirit of turpentine the resin is only soluble hot.—*Rev. Chim. Industr.*, August, 1921.

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Latest Patent Applications.

24139—Baddiley, J.—Manufacture of 1: 4 naphthol sulphonic acid. September 10.

23724—Baker & Sons and Perkins, Ltd., J.—Manufacture of paper for filtering. September 6.

23741—Casale, L.—Process for synthetic production of ammonia. September 6.

23964—Craig, E. N.—Production of oxides of tungsten and molybdenum. September 8.

23637—Vaines, R.—Process for rendering chlorides of ketone soluble by means of alkalies. September 5.

Specification published this Week.

144306—American Smelting and Refining Co.—Method of making sulphur dioxide.

Abstract Published this Week.

Potassium Chloride and Sulphate.—Patent No. 166657.—A process for the recovery of potassium salts from the waste liquor obtained in the rum industry has been Patented by Mr. M. Bird, of Port Mourant, Berbice, British Guiana. After crystallizing out the cane sugar and distilling of the rum, waste heat produced in the factory is employed to effect the evaporation and charring. The liquor, which is first preferably neutralized with leave, may be concentrated by passing it slowly over the heated flues leading from the furnaces to the factory chimney, and is then poured into metallic pots. These are placed inside the flues to cause their contents to char. The residual mass has a content of phosphoric acid and nitrogen and is used as such as a manure, or the potassium chloride and sulphate may be leached out with water. Alternatively, the liquor concentrated as above described may be charred or incerated by other means.

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THE CHEMICAL NEWS
VOL. C

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

EDINBURGH, 1921.

DISCUSSION ON THE AGE OF THE EARTH.*

1. *Opening Remarks.*

By the Right Hon. LORD RAYLEIGH, F.R.S.

IN view of the past history of this subject, it seems particularly important to keep our eyes open to all possibilities, and to welcome evidence from any quarter. Lord Kelvin in the last generation, attempted to set a limit of time to the duration of the sun's heat. And also, from consideration of the earth's internal heat, he argued back to the time when the surface was too hot for the presence of living beings.

As regards the earth's heat, it is now generally known that the premises of Lord Kelvin's calculations, carefully particularised by him, are upset by the discovery of radioactive substances in the earth. In 1906, I made a determination of the amount of radium in the superficial parts of the earth which are alone accessible. From the radium analysis we can calculate the amount of uranium and other associated substances, and the thermal output from them. The result is to show that if we suppose the same radium content to extend to a depth of some 20 miles, the whole output of heat would be accounted for, without assuming that any of it comes from primeval store as postulated by Lord Kelvin. It is surprising, in fact, that the output is not greater. We are puzzled at the present time to account for the existing state of things, and cannot use it as a firm basis from which to explore the past.

Next, as to the sun's heat. Lord Kelvin's argument was that we knew of no source at all adequate to supply the existing output of solar energy except secular contraction; and even this was not enough to account for more than 20 million years of solar heat in the past. Although we still do not know definitely of such a source, yet we are now compelled to admit that it must exist. Some of the stars (the giant red stars) are radiating energy at something like 1,000 times the rate that the sun does. They ought, according to the contraction theory, to have expended an appreciable fraction of their total energy in historical times. No one will maintain that this has occurred, and if not, there must be some source of supply other than contraction. If this is admitted, Lord Kelvin's argument from the sun's heat fails.

Modern knowledge in radioactivity, on the other hand, seems to give a firm basis for the estimation of geological time. Uranium, for example, goes through a series of changes (radium is one of the stages in its progress), changing eventually into an isotope of lead—that is, an element chemically indistinguishable from lead except a slight difference in atomic weight, and inseparable from ordinary lead by chemical means if once mixed with it. The isotope in question has probably an atomic weight of 206 exactly, as contrasted with 207·1 for ordinary lead, which is doubtless to some extent a mixture of isotopes. Thus the product has a much less atomic weight than uranium (238·5), and the difference represents approximately the weight of helium atoms, which are the debris shed at the various stages of the transformation.

Further, it is well established that a grm. of uranium as found along with its products in rocks and minerals is now changing at a rate represented by the production of $1·88 \times 10^{-11}$ grms. of helium and $1·22 \times 10^{-10}$ grms. of lead isotope per annum. There is every reason to believe that this is also the rate at which 1 grm. of uranium has changed in the past, since the rate is unaffected by any change of temperature or pressure which we can apply.

Minerals containing uranium are always found to contain helium and lead. The helium may safely be treated as wholly a radioactive product. It would be difficult to account for its presence, retained mechanically in the mineral, in any other way. The lead in some cases conforms itself to the expected atomic weight of 206, about one unit lower than common lead, and in such cases we may safely regard the whole of it as a product of uranium disintegration.

Thus, take the broggerite found in the pre-Cambrian rocks at Moss, Norway. The lead in this monad has an atomic weight of 206·06 as determined by Hönigschmid and Fräulein St. Horovitz. The ratio of lead to uranium is 0·113. Taking the lead as all produced by uranium at the rate above given, we get an age of 925 million years. Some minerals from other archæan rocks in Norway give a rather longer age. A determination of the amount of helium in minerals give an alternative method of estimating time. But helium, unlike lead, is liable to leak away, hence the estimate gives a minimum only. I have found in this way ages which, speaking generally, are about one-third of the values which estimates of lead have given, and are, therefore, generally confirmatory, having regard to leakage of helium. This method can be applied to material found in the younger formations. Thus the helium in an eocene iron ore indicated 30 million years at least.

H. N. Russel has recently applied the argument from accumulation of lead to the earth's crust as a whole. He takes the uranium as 7×10^{-6} of the whole, the lead as 22×10^{-6} of the whole. If all the lead were uranium lead, and had been generated since formation of the crust, the time required would be 11×10^{9} years. This is certainly too great. Allowing for the production of some of the lead by uranium, Russel finds 8×10^{9} years as the upper limit. This is about six times the age indicated by the oldest individual radioactive minerals that have been examined.

The upshot is that radioactive methods of estimation indicate a moderate multiple of 1,000 million years as the possible and probable duration of the earth's crust as suitable for the habi-

*British Association, Edinburgh Meeting (Sections A, C, D, K,).

tation of living beings, and that no other considerations from the side of physics or astronomy afford any definite presumption against this estimate. The argument from geology and biology I must leave to our colleagues from other sections. May I venture to say that I for one consider the topics with which they will deal as not less interesting and important than those which it has been my privilege to lay before you?

2. *Remarks by* Prof. J. W. Gregory, F.R.S.

The claim that geological time must be restricted within a score or a few score million years was regarded by most geologists with incredulity, since a score million years was of little more use to geology than the seven days of the Pentateuch. Now that physical evidence allows the age of the earth to be counted by the thousand million years, the problem is of less concern to the geologist, except from the hope that the uranium-lead ratio may fix geological dates in years, and from the interest of reconciling the conflicting results of the different methods.

The geological estimates to which most weight has been attached are based on the saltness of the sea. The salinity argument has been widely accepted as sound in principle; the estimates varied from 70 to 150 million years, and some intermediate length was regarded as inevitable. Allowances were made for various factors; but they added only a few per cent to the total, and did not multiply it by 10 or more.

The validity of the salinity argument may be tested by two checks—the supply of chlorine, and the denudation required to account for the amount of sodium; and as shown by Dr. A. Holmes, each of these indicates a much longer period than the sodium.

The supply of chlorine in igneous rocks is quite inadequate to convert their sodium into chloride. Most of the sodium chloride in river water is probably marine in origin, and only the sodium in the bicarbonate and sulphate is a fresh addition to the sea. On this ground the salinity estimate should be approximately doubled. Again, to obtain all the sodium in the sea from igneous rocks would involve the denudation of improbable volumes of them, and, at the rate usually accepted, the age of the earth should be multiplied three- of four-fold.

The fundamental objections to the salinity argument are against (1) its assumption that the sea was originally fresh, which palæontological evidence renders improbable. The oldest fauna, the Cambrian, has the characteristics of a marine fauna, and the contrast between the fresh-water and marine faunas was as sharp in Palæozoic times as it is to-day. (2) Its omission to allow for the large supplies of sodium chloride raised from beneath the earth's surface by magmatic waters. (3) Its assumption of uniform denudation. The earth has probably undergone deformations that led to alternate periods of quick and slow crustal movement; during the times of repose the surface would have been planed down, rivers would have become sluggish and denudation slow. As the earth is now under the influence of a time of quick movement, denudation is faster than the average. A multiplication of the earth's age five-fold for this difference would not be excessive.

During quick crustal movement volcanic action would be more powerful, and the discharge of hydrochloric acid and sodium in hot springs would be increased; and as denudation is now acting on land in which sodium chloride has been produced in unusual quantities by volcanic action the estimated age of the earth must be again extended. The rythmic acceleration of geological processes lengthens the estimates based on sedimentation, but would affect the biological argument inversely, since at periods of rapid physical change biological change would have been quickened, and thus the occasional abrupt introduction of a new fauna does not necessitate so long an interval as has been thought.

The best-known geological estimates of the age of the earth require to be multiplied ten- or twenty-fold in order to agree with the physical estimates, but this increase is consistent with the geological evidence.

3. *Remarks by* Prof. A. S. Eddington, F.R.S.

A study of the Cepheid variable stars affords strong evidence that the stars have other sources of energy besides that furnished by gravitational contraction. The rate of radiation by δ Cephei is such that it would be necessary for the density to increase 1 per cent in 40 years in order to provide the required energy. The light-change of δ Cephei is believed to be due to a periodity intrinsic in the star (*e.g.* pulsation); it is clear that such an intrinsic period cannot remain unaltered whilst the density changes so rapidly. But the observed change of period of δ Cephei is only 0·008 per annum, or 1 per cent in 58,000 years. The condition of δ Cephei is thus changing at a rate very much slower than that required by the contraction theory. The figures suggest that Lord Kelvin's time-scale should be lengthened 500-fold—at least during this stage of the evolution.

NON-AROMATIC DIAZONIUM SALTS.*

Recent investigations have shown that several series of non-aromatic primary amines possess in varying degrees the property of diazotisability. In certain cases, the existence of a diazo-derivative is inferred from the property of coupling to form azo-derivatives or from the fact that the diazo-group can be replaced by other radicals such as chlorine, but in other instances diazonium salts have actually been isolated. These non-aromatic diazonium salts vary considerably in stability from the exceptionally stable diazonium salts of the pyrazole series to the explosive diazo-derivatives of the thiazole group. Orientation plays an important part in the stability of these compounds, as is shown below in the case of the pyrazole and pyridine derivatives.

The requisite properties for diazotisability appear to be the presence of the group $H_2N—C\langle$ and the possession of a certain degree of unsaturation in the cyclic system in which this carbon atom is included. But it must not be assumed that any base having the foregoing group and belonging to an unsaturated cyclic system is necessarily diazotisable. The absence of diazotisability is noteworthy in the thiophen,

*Report of Committee, consisting of Dr. F. D. Chattaway (Chairman), Prof. G. T. Morgan (Secretary), Mr. P. G. W. Bayly and Dr. N. V. Sidgwick. Drawn up by Prof. G. T. Morgan and Mr. Henry Burgess. Presented at British Association, Edinburgh Meeting (Section B).

furane, and pyrrole series in spite of the close relationship between the first of these series and the aromatic compounds.

Pyrazole Series.—In this group the effect of orientation on the stability of the diazonium salts is well marked. 4-amino-3 : 5-dimethylpyrazole when diazotised in the usual manner furnishes 3 : 5-dimethyl pyrazole-4-diazonium chloride stable in hot aqueous solutions and up to 150° C. in the dry state. This salt, which retains its diazo nitrogen and coupling power for an indefinite time, gives rise to sparingly soluble diazonium platinichloride and aurichloride (Morgan and Reilly, *T.*, 1914, cv., 435). Other 4-aminopyrazole derivatives yield similarly stable diazo-derivatives (Knorr, *B.*, 1895, xxviii., 717; Michaelis and Schafer, *A.*, 1915, cdvii., 229; Michaelis and Bressel, *A.*, 1915, cdvii., 274).

When the diazonium group is in position 5 the product is distinctly less stable, for 1-phenyl-3-methyl-4-ethylpyrazole-5-diazonium chloride decomposes at room temperature in a few hours, and quickly on warming (Mohr, *J. Pr. Chem.*, 1914, (2) xc., 509). 1-phenyl-3-methyl-5-aminopyrazole I containing a labile hydrogen atom in position 4 gives only 12 per cent of diazonium compound (Mohr, *loc. cit.*) (see Fig. 1).

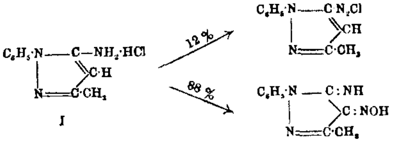


FIG. 1.

Substitution of the labile hydrogen by an alkyl group prevents the second reaction, and diazotisation takes place quantitatively.

In the case of 1-phenyl-3-methyl-4-amino-5-anilinopyrazole an azimino compound II is formed unless diazotisation is carried out in strong acid (Michaelis and Schafer, *loc. cit.*) (Fig. 2).

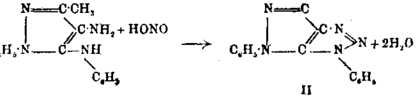
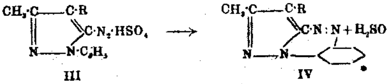


FIG. 2.

On adding a solution of any diazonium salt of the general formula III to boiling dilute sulphuric acid the diazonium nitrogen is retained and a triazine IV is produced (Fig. 3).



R = an alkyl group.

FIG. 3.

In this series replacement of the diazonium complex by iodine (Knorr, *loc. cit.*) and by the triazo group has been effected. It is noteworthy that 4-triazo-3 : 5-dimethylpyrazole V, a well-defined crystallisable compound, has the remarkable property of giving distinctive colour reactions with all phenolic substances not containing nitro-groups (*Fig. 4*).

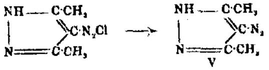
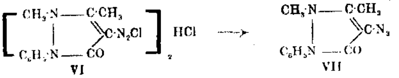


FIG. 4.

Pyrazolone Series.—Very stable salts are obtained on diazotising the hydrochlorides of the amino-pyrazolones; the products are crystallisable from hot aqueous solutions, and are stable in a dry state for an indefinite time (Knorr and Geuther, *A.*, 1896, ccxciii., 55; Knorr and Stolz, *A.*, 1896, ccxciii., 58; Michaelis, *A.*, 1906, cccl., 288). The acid diazonium salts, VI., from amino antipyrine (Morgan and Reilly, *T.*, 1913, ciii., 808, 1494) are exceptionally stable and recrystallisable and in these respects are unlike the decomposable acid diazonium salts of the aromatic series (Hirsch, *B.*, 1897, xxx., 1148; Hantzsch, *ibid.*, 1153). Double salts with auric chloride and platinic chloride have been prepared and are stable up to 120° C. in the dry state (Morgan and Reilly, *loc. cit.*) (Fig. 5).

Diazoamino derivatives are formed with fatty amines such as dimethylamine, and are stable up to 120° C., when they begin to decompose into the amine and a complex pyrazolone derivative, the constitution of which has not been settled (Stolz, *B.*, 1908, xli., 3849). In this series, as in the

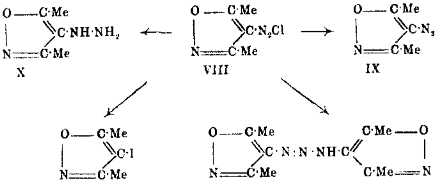
pyrazoles, the diazonium complex has been replaced by iodine (Michaelis, *loc. cit.*), and by the triazo group (Forster and Muller, *T.*, 1909, xcv., 2072) VII, but reduction with stannous chloride does not lead to a readily isolated hydrazine, probably owing to condensation taking place with the carbonyl group in the ring (Morgan and Reilly, *loc. cit.*).



VI VII

Fig. 5

Iso-oxazole Series.—4-amino-3:5-dimethyl*iso*-oxazole has recently been prepared and diazotised. The diazonium chloride VIII is very soluble and is much less stable than the corresponding pyrazole compound. The diazonium aurichloride is sparingly soluble and stable on keeping in the dry state at the ordinary temperature (Morgan and Burgess, *T.*, 1921, cxix., 697) (Fig. 6).



X VIII IX XI XII

Fig. 6.

The diazonium complex is readily replaced by the triazo group IX and by iodine XI. The diazonium chloride reacts, with the base forming a well-defined colourless diazoamine XII, and is reduced by stannous chloride to the hydrochloride of the hydrazine X.

Glyoxaline Series.—The bases of this group have not been studied exhaustively as regards diazotisability, but 2-aminoglyoxaline when treated successively with nitrous acid and alkaline β naphthol gave a brownish-red, soluble azo-derivative, which does not appear to have been isolated (Pyman and Fargher, *T.*, 1919, cxv., 247).

Triazole Series.—When 5-aminotriazoles are diazotised in hydrochloric acid solution, the resulting salt decomposes fairly quickly at 0° C. into nitrogen and the corresponding chlorotriazole (Thiele and Manchot, *A.*, 1898, ccciii., 33). If, however, oxy-acids are used instead of hydrochloric acid, more stable diazonium salts are obtained, although these are too unstable to be isolated (Morgan and Reilly, *T.*, 1916, cix., 155). The sparingly soluble diazonium aurichloride has been isolated and is stable in the dry state. When a solution of the diazonium nitrate is evaporated to dryness in vacuo over potassium hydroxide, a colourless *iso*diazo hydroxide is obtained, which is quite stable at 100° C., and couples only after being acidified. The diazonium complex is replaced by hydrogen on reduction with alcohol, and with stannous chloride the hydrazine is obtained (Thiele and Manchot, *loc. cit.*).

Thiazole Series.—2-Aminothiazole reacts in the same way as aminotriazole with nitrous acid. In hydrochloric acid solution an unstable diazonium chloride is produced. This decomposes rapidly at 0° C. into nitrogen and chlorothiazole. Oxy-acids give more stable salts, especially sulphuric acid. The perchlorate is explosive even at 0° C. The yellow diazonium aurichloride is sparingly soluble, and is stable in the dry state, but becomes brown on washing with water. In feebly acid solution aqueous sodium nitrite gives an unstable orange-red powder, probably an *isodiazo* compound (Morgan and Morrow, *T.*, 1915, cvii., 1291). Reduction of the diazonium sulphate with alcohol causes the replacement of the diazonium complex by hydrogen (Hantzsch and Popp, *A.*, 1889, ccl., 274).

Pyridine and Quinoline Series.—Nitrous acid acts on the amines derived from these bodies in the same way. The α and γ amines when treated in hydrochloric acid solution yield forthwith the corresponding chloro derivatives. This reaction suggests a rapid decomposition of a probable intermediate diazonium chloride (Marckwald, *B.*, 1898, xxxi., 2496; *B.* 1894, xxvii., 1325; H. Meyer, *Monatsch.*, 1894, xv., 173; Claus and Howitz, *J. Pr. Chem.*, 1894, (2) l., 23). Oxy-acids have not been used and these would probably give better results. The β-amines form diazonium chlorides, which do not appear to have been isolated but have been coupled with phenols (Mohr, *B.*, 1898, xxxi., 2495; Watson and Mills, *T.*, 1910, xcvii., 743). The corresponding $\beta\beta$-diazoaminopyridine is a yellow, crystalline, stable compound (Mohr, *loc. cit.*).

THE SPECTRA OF HYDROGEN FROM LONG VACUUM TUBES.*

By Prof. R. W. WOOD, For.Mem.R.S.

The spectrum of hydrogen obtained in the laboratory exhibits a Balmer series of lines, of which only twelve members are found under ordinary conditions. Thirty of the lines have been recorded in the solar spectrum. The impossibility of obtaining the higher members of the series in the laboratory results, in part at least, from the presence of a continuous spectrum and the so-called secondary sepctrum.

By employing vacuum tubes of unusual length it has been found that the secondary spectrum appears only at the ends, the central portion radiating a very pure Balmer spectrum. By this means it has been possible to record the series down to the twentieth line. Very remarkable phenomena have been observed witb tubes of this type. Starting with a very feeble current, the secondary spectrum only is in the tube, the Balmer lines being absent. As the current is increased the Balmer lines appear and increase in intensity, while tbe secondary spectrum fades away, passing through a minimum value of about one-fiftieth of the intensity shown at the ends of the tube, after wbich it slowly increases in intensity.

If a heavy current is employed, there is an explosive flash of the secondary spectrum at the moment of closing tbe switch, the Balmer lines being feeble. In about one-sixtieth of a second, the secondary spectrum has nearly disappeared (reduced to one-fiftieth of its initial value) and the Balmer lines have risen to full intensity. These phenomena occur only when a trace of oxygen or water vapour is present. With pure hydrogen, continued operation of the tube eventually causes the complete disappearance of the Balmer series, the secondary spectrum remaining, and the colour changing from fiery purple to white. A new spectrum has been found which is much more complicated in structure than the secondary spectrum. This appears when the tube is in the condition best suited to the exhibition of the Balmer series.

THE RECEPTION OF WIRELESS WAVES ON A SHIELDED FRAME AERIAL.*

By ALAN A. CAMPBELL SWINTON, F.R.S.

The paper describes experiments in receiving the spark emission from the Eiffel Tower on a small frame aerial placed inside a tube of wire network with open ends. It was hoped to obtain improved directional properties, but, though the presence of the tube weakened the signals, it was found that altering its direction did not affect them, nor were the signals further weakened by closing the open ends of the tube by wire grids.

The tube was next replaced by a sheet copper box with one open end. In this was placed, not only the frame, but also the amplifier and all the other apparatus, the telephone being listened to through a rubber pipe. Signals were heard of equal strength with the open end of the box pointing towards, or directly away, from Paris; but ceased when the box was turned so that the open end faced at right angles to Paris, the frame still pointing to Paris; or when the open end was completely closed with copper or tinfoil cover. In the latter case the signals were still audible unless the cover actually touched the box on all sides. For other positions of the box with the end open, signals could only be heard when the relative positions of the box and frame were such that a prolongation of the plane of the frame towards or away from Paris, no matter which, came out of the open end clear of the copper sides of the box.

*Read before British Association, Edinburgh Meeting (Section A).

THE NORWEGIAN INDUSTRIES FAIR.

This Fair, held in Christiania, September 4—11, appears to have been highly successful. From an account sent to us by Dr. Sebilien, much business appears to have been done; buyers came from practically every country in Europe and overseas; the number of exhibitors was double that of last year, and the area of the Exhibition was much greater.

The capital purpose of the Fair was to promote the sale of Norwegian products in home and foreign markets.

The Chemical Industry, particularly the manufacture of sulphuric acid and fertilisers, is active, and is largely helped by the abundance of water-power. The Norwegian waterfalls are said to be capable of producing ten million borse-power.

Electricity was well represented in the Fair; there was a good show of dynamos and electric heating appartus.

Cellulose, paper pulp, rubber, and ebonite wares and coal-tal products were shown.

At a meeting of Norwegian merchants and financial representatives, the situation of the export trade of the country was discussed. Although Norway has been gifted witb a lot of raw stuffs (about every chemical element except tin and mercury is found in Norway), and with more energy in its waterfalls than any other country in Europe, it was statistically shown that few nations have to seek their conditions for living outside its own frontiers more than the Norwegian. All the Norwegian industry of machinery and a very great part of its chemical industry is based on shipping and export. The lucky geographical situation of the country in connection with its many lucky conditions for export will in the long run come forward and bring up the country from the difficulties tbat just now are predominating.

It was suggested that the Norwegian Industrial Fair ought to be a fixed annual institution, and in connection with the same, should grow up an opening term for sale of the more essential part of the Norwegian export trade—paper and paper-pulp, trade in fish oil, &c.

Sir John Cass Technical Institute.—A new development in the activities of this Institute is the introduction of a course of lectures in Petroleum Technology. The course will be opened by a special lecture at the Institution, Jewry Street, Aldgate, E.C., on Monday, October 10, at 7 p.m., by E. H. Cunningham, Esq., B.A., F.R.S.E., M.Inst.P.T., F.G.S., on the "Geology of Petroleum." The Chair will be taken by Sir Frederick Black, K.C.B.

GERMANIUM.*

I.—Occurrence; Extraction from Germanium-bearing Zinc Oxide; Non-Occurrence in Samarskite.

By L. M. DENNIS and JACOB PAPISH.

Historical.

Mendeléeff, in 1871, predicted the existence of an element to which he gave the name ekasilicon. In 1885 there was discovered at the Himmelsfürst mine near Freiberg in Saxony a new mineral which Weisbach named argyrodite (*Neues Jahrb. f. Miner.*, 1886, ii., 67). Richter made a superficial examination of this mineral, and found that its chief constituents were silver and sulphur. Clemens Winkler then made careful analysis of the compound, and found that contained from 73 to 75 per cent of silver, 17 to 18 per cent of sulphur, and smaller amounts of mercury, iron, and arsenic. The sum of these constituents, however, amounted to only 93 to 94 per cent of the weight of the sample taken, and careful search for the cause of this discrepancy led Winkler to the discovery of a new element, to which he gave the name germanium (*Ber.*, 1886, xix., 210). He at first thought that this new element was an analogue of antimony, and that it would find place in the periodic system between antimony and bismuth, but von Richter, Mendeléeff, and Lothar Meyer, in separate letters to Winkler early in 1886, pointed out that the new element was very probably identical with the ekasilicon whose properties had been predicted by Mendeléeff fifteen years earlier, and this view was borne out by Winkler's later careful and brilliant experimental study of the element and its compounds (*J. prak. Chem.*, 1886, (New Series xxxiv.), cxlii., 177; 1887, (New Series xxxvi.), cxliv., 177).

Under Winkler's direction, a large amount of ore-containing argyrodite was subjected to chemical treatment for the extraction of germanium, but it was found that the material contained on an average not over 0·03 per cent of the element. The amount of germanium that he recovered was about 150 grms.

Occurrence.

(*A*) *In Sulphide Materials.—In Argyrodite.*—The mineral argyrodite is of rare occurrence, and no further appreciable amount of it has been furnished by the Freiberg district since Winkler's investigation in 1885. It is a sulphide of silver and germanium corresponding in composition to the formula $4Ag_2S.GeS_2$, with a germanium content of about 7 per cent. In 1893 Penfield (*Amer. Jour. Sci.*, 1893, (3), xlvii., 107) announced the discovery of argyrodite in Bolivia, stating at the same time that very little was known concerning the exact locality and mode of occurrence of this mineral.

It is of interest to note that two mineral specimens which had been found in Freiberg in 1817 and in 1821, respectively, were identified, one by Kolbeck (*Zentrb. f. Min. u. Geol.*, 1908, 331), and the other by Frenzel (*Jahrb. f. Berg- u. Hüttenwesen*, 1900, 61; *Chem. Zentrb.*, 1901, i., 590) as being varieties of argyrodite.

In Canfieldite.—This mineral, which was first described by Penfield in 1894 (*Amer. Jour. Sci.*, 1894, iii., xlvii., 451), is in reality a stanniferous argyrodite. It was discovered in La Paz, Bolivia, and upon analysis was found to correspond to the formula $4Ag_2S.(Sn.Ge)S_2$, germanium replacing tin isomorphously. The germanium content of this particular mineral was given by Penfield as 1·8 per cent, while the content of tin was nearly 7 per cent.

A stanniferous argyrodite containing almost 5 per cent of germanium was described by Prior and Spencer in 1898 (*Miner. Mag.*, 1898, xii., 5). The sample upon which they worked came from Aullagas, Bolivia. These investigators also examined a sample of the so-called brongniardite from the same locality, and found that it was nothing but a variety of stanniferous argyrodite.

In Frankeite.—Stelzner (*Neues. Jahrb. f. Min.*, 1893, xi., 114) proposed the name frankeite for a Bolivian mineral, the composition of which, according to Winkler (*ibid.*, p. 119), corresponds to the formula $5PbS.2SnS_2.Sb_2S_3$. He found that it contained about 0·1 per cent of germanium. Khrushchov (*Zhurnal Russkago Fiziko-Khimicheskago Ob-va-* 1892, xxiv., Sec. 1, 30) reported that he also had found traces of germanium in frankeite.

In Blendes.—Urbain (*Compt. Rend.*, 1909, cxlix., 602) made a spectrographic investigation of 64 samples of blendes and found that 38 of them showed the presence of germanium. Five of these contained the element in amounts sufficient to disclose all of its spectrum lines. These five richest samples came from Webb City, Missouri, Stolberg near Aachen, European Turkey (in 1909), Raibl in Austria (Urbain gives the source of this sample as "Raibl, Corinthie"; it should read "Carinthie, eng. Carinthia"), in Austria, and Mexico. In conjunction with Blondell and Obiedoff, Urbain (*Compt. Rend.*, 1910, cl., 1758) extracted germanium from Mexican blendes and obtained 5 grms. of germanium from about 550 kilogrms. of the mineral.

Hillebrand and Scherrer (*J. Ind. and Eng. Chem.*, 1916, viii., 225) subjected various zinc ores to spectroscopic examination and reported the presence of germanium in sulphides from Missouri and Idaho.

Buchan (*J. Ind. and Eng. Chem.*, 1916, viii., 585; 1917, ix., 661) found germanium in zinc oxide that had been prepared from spelter residues. It was his belief that this material had been obtained either from a Wisconsin or a Missouri ore or from a mixture of both, and that the germanium in the final product had been greatly concentrated during the metallurgical treatment to which the ore had been subjected. The amount of germanium calculated as germanium dioxide in the original ore was estimated by him to be about 0·01 per cent.

(*B*) *In Minerals Containing Titanium, Zirconium, and Columbium.*—In his prediction of the existence of ekasilicon, Mendeléeff (*Ann.*, Eigth Suppl., 1872, p. 200) expressed the opinion that this element should be looked for in complex minerals containing titanium, zirconium, and columbium. The later discovery of ger-

*Contribution from the Department of Chemistry of Cornell University. This article is based upon a part of the thesis presented to the Faculty of the Graduate School of Cornell University by Jacob Papish in partial fulfilment of the requirements for the degree of Doctor of Philosophy.

manium and the striking agreement of its properties with those predicted for ekasilicon stimulated the search for this element in minerals of the above character.

In Fergusonite.—Krüss and Nilson (*Ber.*, 1887, xx., 1696) examined the fluoride residues from fergusonite, but failed to find germanium in them. Khrushchov (*loc. cit.*), on the other hand, reported that he found traces of germanium in this mineral.

In Euxenite.—In 1888, Krüss (*Ber.*, 1888, xxi., 131) announced the discovery of germanium in euxenite. He surmised that the germanium in this mineral replaced a part of tetravalent titanium and for this reason he took up a search for germanium in other titaniferous minerals, such as rutile, yttrotitanite, and wöhlerite. The results of this investigation were never published, and it is therefore fair to assume that Krüss did not find germanium in these minerals.

Lincio (*Zentrb. f. Min.*, 1904, 142) re-examined euxenite and failed to find even a trace of germanium in the mineral. He also analysed two samples that had been left by Krüss, and that had been marked "germanium oxide" and "germanium sulphide" from euxenite residues, and found the first to consist of tantalic and columbic acids, and the second of tantalic and columbic acids and sulphur. No trace of germanium was found in either sample. This would seem to establish the fact that euxenite is not to be regarded as a germanium-bearing mineral.

In Samarskite.—Khrushchov (*loc. cit.*) stated that he had found in American samarskite as much as 1·5 per cent germanium. His statement was given publicity in mineralogical and chemical periodicals and from these it found its way into chemical handbooks and textbooks. The correctness of this statement was later challenged by Lincio (*loc. cit.*), and results obtained in this laboratory confirm Lincio's view (see ante).

(*C*) *In the Sun.*—In a provisional table of thirty-six elements present in the sun, Rowland ("John Hopkins Univ. Circular," No. 85; *Amer. Jour. Sci.*, 1891, xli., 243) placed germanium thirtieth in respect to the intensity of spectrum lines, and thirty-third in respect to he number of lines.

(*D*) *In Mineral Waters.*—Bardet (*Compt. Rend.*, 1914, clviii., 1278) examined various mineral waters spectroscopically, and found that germanium was present in many of them. He succeeded in extracting 60 mgrms. of germanium dioxide from about 100 kilogrms. of residues, chiefly calcium carbonate, obtained in the manufacture of Vichy salts from the natural waters. This amount of germanium dioxide represented 250,000 litres of original Vichy water, and corresponded to 0·00024 mgrms. of germanium dioxide per litre of water, a quantity too small to render these waters practicable sources of supply of germanium.

(*E*) *In Zinc Carbonate Ores.*—Hillebrand and Scherrer (*loc. cit.*) observed that some zinc carbonate ores from Colorado, Nevada, and Utah contain spectroscopic traces of germanium.

(*F*) *In Marine Plants.*—Cornec (*Compt. Rend.*, 1919, clxviii., 513), while making a spectrographic study of the ashes of marine plants, detected slight traces of germanium in the ashes of *Laminaria.*

Experimental.

(*A*) *Material.*—Argyrodite and canfieldite, which at present are the only materials known to contain germanium as a definite constituent, are too rare to be regarded as sources of supply of the element. The extraction of germanium from spring waters, although strongly recommended by Bardet, is at present quite impracticable, because 1 kilogrm. of the residue contains only 0·6 mgrm. of germanium oxide. The extraction of germanium directly from blendes, as has been carried out by Urbain, is a very expensive and tedious operation. The most promising source of the element at the present time is the concentrate from certain residues obtained in the smelting of American zinc ores. Buchanan (*loc. cit.*) reported that one such residue contained as much as 0·25 per cent of germanium dioxide. A large supply of this most valuable material was presented to the Department of Chemistry of Cornell University by the New Jersey Zinc Company, and the present investigation, as well as others that will follow from this laboratory, would not have been possible except for the generous co-operation of this Company. Concerning the origin of this material, Mr. W. M. Kelsey (letter to L. M. Dennis, Sept. 3, 1919), Superintendent of the Palmerton plant of the New Jersey Zinc Company, states that it was obtained "by a fire concentration of certain residues produced in the ordinary process of smelting for zinc. The original ore was a mixture of high-grade sulphides from the Wisconsin and Missouri fields, roughly in the ratio of two parts of Wisconsin ore to one part of Missouri ore."

(*B*) *Extraction of Germanium.*—None of the various methods that were employed by Winkler for the extraction of germanium from argyrodite are adapted to the separation of the element from the germanium-bearing zinc oxide, because the association of elements in this latter material is quite different from that in argyrodite. Zinc oxide is, of course, present in preponderating amount, and the concentrate further contains considerable quantities of lead, arsenic, and cadmium, and also traces of other elements, among them being indium, tin, and antimony.

Preliminary trials were made of a variety of possible methods of separation, but as none of these was found to be satisfactory, descriptions of them will not here be given. The procedure that was finally adopted is based upon the volatility of germanium tetrachloride, and is an elaboration of the method described by Buchanan (*J. Ind. and Eng. Chem.*, 1916, viii., 585). The essential feature of this process consists in treating the crude zinc oxide with hydrochloric acid and then distilling off germanium tetrachloride in a current of chlorine. The chlorine maintains the arsenic in pentavalent form, and thus prevents the distillation of arsenic trichloride with the germanium tetrachloride.

In the first trials of this method, portions of the crude zinc oxide of from 250 to 1000 grms. each were treated with hydrochloric acid, chlorine gas was passed through the apparatus, and the mixture was heated to effect the distillation of the germanium tetrachloride. This gave a product substantially free from arsenic, but the necessity for long passage of large amounts of chlorine through the apparatus rendered the procedure un-

suited to the extraction of germanium on a large scale from several hundred pounds of the crude material. Browning and Scott (*Amer. Jour. Sci.*, 1917, (4) xliv., 313; 1918, xlvi., 663) substituted potassium permanganate, manganese dioxide, potassium chlorate, or potassium dichromate for chlorine. They used the method for the detection of germanium in very small samples that contained less than a grm. of As_2O_3 or As_2O_5, and not more than 5 mgrms. of germanium. But even so they found that when from 0·3 to 0·5 grm. of As_2O_3 was used, some arsenic appeared in the distillate. It is apparently essential that if the formation of arsenic trichloride and its consequent appearance in the distillate are to be avoided, the concentration of chlorine must be high throughout the whole distillation. Fresenius (*Zeit. f. anl. Chem.*, 1862, i., 447) states that when a mixture of sodium arsenate and concentrated hydrochloric acid is distilled, small amounts of arsenic are volatilised. Mayrhofer (*Liebig's Ann.*, 1872, clviii., 326), in attempting to remove arsenical impurities from hydrochloric acid noticed that even when the acid was first treated with chlorine or when some pyrolusite was added to the acid and it was then distilled, small amounts of arsenic were always found in the distillate. Hehner (*Analyst*, 1902, xxvii., 268) distilled arsenic acid with strong hydrochloric acid, and obtained comparatively large quantities of arsenic in the several fractions of the distillate. He states that "a similar result was obtained when potassium permanganate had been added before the beginning of the distillation, or, in other words, when the distillation was begun in the presence of chlorine."

In an investigation of the reaction between hydrogen sulphide and arsenic pentoxide in the presence of hydrochloric acid, Usher and Travers (*Jour. Chem. Soc.*, 1905, lxxxvii., 1370) studied the reaction between arsenic pentoxide and hydrogen chloride in sealed tubes. They concluded that the reaction is that expressed by the equation

$As_2O_5 + 10HCl \rightleftharpoons 2AsCl_3 + 2Cl_2 + 5H_2O$, the equilibrium shifting rapidly to the right with increasing concentration of hydrogen chloride.

These observations upon the reduction of arsenic pentoxide by concentrated hydrochloric acid and volatilisation of arsenic trichloride when such a mixture is distilled, have been sustained by the experimental evidence accumulated in this laboratory during the progress of the investigation here described. When potassium permanganate was added to the crude zinc oxide, and this was then distilled with an excess of concentrated hydrochloric acid, arsenic trichloride passed into the distillate. To maintain the concentration of chlorine, the procedure was modified by slowly running into the flask a solution of the potassium permanganate during the distillation with hydrochloric acid. It was found that the dilution of the acid soon rose to such an amount that the germanium tetrachloride instead of distilling off was hydrolysed in the flask. To ascertain whether a mixture of sodium arsenate and sodium germanate, when distilled with an excess of concentrated hydrochloric acid, would yield arsenic trichloride in the distillate, a mixture of the oxides of arsenic and germanium was fused with a slight excess of sodium peroxide, the fused mass was dissolved in water, and the solution was heated to boiling. It was then cooled, an excess of hydrochloric acid was added, and the liquid was distilled. The distillation gave a yellow precipitate, with hydrogen sulphide which indicated the presence of arsenic. In another experiment lead dioxide was used in place of sodium peroxide. Arsenic here also passed into the distillate. These experiments, as well as the observations of previous investigators, indicate that if the volatilisation of arsenic acid is reduced to arsenic trichloride during distillation with hydrochloric acid unless high concentration of chlorine throughout the distillation is maintained.

In checking the accuracy of this separation of arsenic from germanium by distillation, it was further necessary to ascertain whether arsenic trioxide when dissolved in sodium hydroxide, saturated with chlorine, and then acidified with hydrochloric acid, would yield any arsenic trichloride when distilled in a current of chlorine.

This was tested experimentally by dissolving 5 grms. of arsenic trioxide in 20 cc. of a 30 per cent solution of potassium hydroxide, saturating this solution with chlorine, and then, without interrupting the current of chlorine, adding 190 cc. of pure concentrated hydrochloric acid, and distilling. A Reitmair-Stutzer bulb was used to prevent, so far as possible, the mechanical passage of some of the liquid into the distillate. Two fractions of 40 cc. each were obtained. Each of these was saturated with hydrogen sulphide. After twelve hours there separated a few small yellow particles that resembled sulphur. These were removed with the aid of a glass rod, and were treated with nitric acid, the acid being warmed over a small flame. The particles melted and coalesced, forming a globule about 1 mm. in diameter. On cooling, this solidified to a hard yellow particle, which was in all probability sulphur, but it was tested for arsenic by adding ferrous sulphate to reduce the nitric acid, then adding dilute sulphuric acid, warming the mixture to remove oxides of nitrogen, and finally subjecting the material to the "modified Gutzeit test" (Dennis and Whittelsey, "Qualitative Analysis," revised edn., p. 31). The reaction was allowed to proceed for ten minutes, but no discolouration of the crystal of silver nitrate was discernible.

To ascertain whether there might still be a trace of unprecipitated arsenic in the two fractions of the distillate, which was somewhat milky because of liberated sulphur, they were united and placed in a small distilling flask that was provided with a separatory funnel. Several portions of nitric acid were successively added through the funnel and the liquid was boiled until almost all chlorine was removed. More nitric acid was then added, and the solution was evaporated almost to dryness. This was then subjected to the Gutzeit test in the manner above described. A very slight yellow colouration of the crystal of silver nitrate appeared at the end of fifteen minutes. This may indicate that a mere trace of arsenic passes over as arsenic trichloride under the above conditions, or that a minute amount of the solution was carried over mechanically.

In the above experiments, blank tests showed the absence of arsenic in the hydrogen sulphide, and a trial of the Gutzeit method, in which a

minute quantity of arsenious sulphide was added, yielded at once a strong, positive result, the crystal of silver nitrate beginning to darken immediately and becoming black at the edges after only a few moments.

Müller (*Journ. Am. Chem. Soc.*, 1921, xliii., 1085), in a recent article upon the atomic weight of germanium, states that "the chlorine-hydrochloric-acid distillation process, though adequate for the removal of silica and tin, can hardly be accepted as a means of eliminating the last traces of arsenic from germanium compounds. Four redistillations of the chloride from hydrochloric acid solution in a stream of chlorine failed to remove the last of the arsenic." Careful perusal of his article fails to reveal experimental support for this statement. In fact, in his description of the purification of germanium, he remarks that the precipitation of redistilled germanium tetrachloride by hydrogen sulphide yielded a "snow-white germanium sulphide." The point is of importance, and the possible presence of arsenic in the distilled germanium tetrachloride will be carefully followed during a further work in this laboratory. Inasmuch as only a very faint trace of arsenic was found in the distillate from As_2O_3 in hydrochloric acid in a current of chlorine, it is probable that a second distillation of germanium chloride in a rapid current of chlorine will yield a product free from arsenic.

To avoid the necessity for the use of the very large amounts of chlorine that would be called for if the germaniferous zinc oxide were directly distilled with hydrochloric acid in a current of chlorine for the separation of germanium, it was decided to distil off germanium tetrachloride and arsenic trichloride together from the crude zinc oxide and thus to effect, as a first step, the separation of the germanium from the large amount of the zinc oxide that is present in the original material.

Apparatus.

The unit still consists of a round-bottom 5-litre Pyrex flask that is supported on an asbestos "collar" 10 cm. high, the collar resting on an iron plate and this on a strong tripod. (This device for heating glass or porcelain vessels that contain a mixture of liquid and solid materials has been in use in the Cornell Laboratory for several years. A "collar" is made from asbestos board ⅛in. to ¼in. thick, a strip of the board of the desired width being first thoroughly wet with water, then bent into a circle and fastened at the overlapping ends with iron or copper wire, and finally dried. The "collars" may, of course, be made of any desired diameter. The collar is placed upon an iron plate about ⅛in. thick, and this plate rests in turn upon an iron tripod. If the collar is dipped in a dilute solution of sodium silicate, it becomes stiff when dry, and although somewhat brittle, its life is prolonged by the treatment. A glass flask or porcelain evaporator placed on one of these collars does not come into direct contact with the gas flames under the iron plate, and local heating that would result from the direct application of the flame to the container, which often causes the fracture of the vessel, is thus avoided. The collar is especially useful in the long digestion of a powdered mineral with acids.) A two-hole rubber stopper in the neck of the flask carries a bent glass tube for connection with a Liebig condenser, and through the other opening of the stopper is inserted a short glass tube through which the desired amount of concentrated hydrochloric acid may be blown into the flask by air pressure from a large, graduated bottle. After the acid has been driven into the flask in the actual operation, the glass tube is replaced by a solid glass plug. A bent glass tube is attached to the further end of the condenser by means of a short piece of rubber tubing. This glass tube is about 10 mm. in diameter, and reaches nearly to the bottom of a 4-litre bottle, which serves as a receiver. The iron plate upon which the collar rests is heated with a large Meker burner, and to avoid loss of heat, the tripod is surrounded by sheets of asbestos board. The duration of each distillation is further shortened by covering the upper part of the flask with an asbestos jacket. This jacket is made by first covering that part of the flask which projects above the collar with a layer of moist filter paper. Asbestos felt which been soaked in water is then laid upon the paper in overlapping pieces and smoothed down to an even continuous layer. Wet asbestos cement is then laid over the whole exterior of the jacket. The opening in the top of the jacket is made sufficiently large to permit of the removal of the cap from the flask. The cap is allowed to dry on the flask and is then removed, and its lower edge and the upper rim are dipped in a solution of sodium silicate to stiffen them. The receiver stands in an earthenware jar.

Distillation.

One kilogrm. of the crude zinc oxide is introduced into the flask, water is placed in the receiver to such depth as just to cover the end of the glass tube, and the earthenware jar in which the bottle stands is filled with cracked ice. 2500 cc. of commercial concentrated hydrochloric acid (1 : 18 sp. gr.) is next driven into the flask through the glass tube in the stopper, and the tube is then replaced by a solid glass plug. The heating of the flask is begun and continued until 2000 cc. of the distillate has collected, this amount having been shown spectroscopically to suffice for the recovery of all the germanium. The flask is then disconnected from the condenser, and the inner tube of the condenser and the tube attached to its far end are rinsed out into the receiver with a little concentrated hydrochloric acid. At the end of the distillation the material in the receiver is a turbid liquid consisting essentially of hydrochloric acid carrying germanium and arsenic in solution. The duration of a distillation is usually from three to five hours. In this laboratory the stills were set up in pairs, and at one time twenty such stills were in simultaneous operation.

The Precipitation of Germanium and Arsenic by Hydrogen Sulphide.

The acid distillate may now be precipitated by hydrogen sulphide in such manner as to throw down all of the arsenic and germanium that are present, or the conditions may be so regulated as to cause the precipitation of arsenic trisulphide alone or mixed with only a very small amount of germanium sulphide. This last procedure was used by Winkler (*J. f. prakt. Chem.*, 1886, cxlii., 194), and is now being studied in this laboratory.

The method that we have employed up to the present time involves the simultaneous precipitation of the sulphides of germanium and arsenic.

Successive distillates are poured into a 15-litre glass bottle until about 10 litres of the solution has been collected. Since the precipitation of germanium disulphide is most complete when the acid concentration is about 6N, concentrated sulphuric acid is slowly added to the contents of the bottle until the acidity is brought to about this point. The acid is run in from a separatory funnel that passes through one opening of a two-hole rubber stopper inserted in the neck of the bottle. A short, bent, delivery tube is placed in the other opening of the stopper, and this tube dips into a litre of 6N sulphuric acid that has been saturated with hydrogen sulphide. This serves to stop any germanium tetrachloride that might be volatilised during the addition of the sulphuric acid. Washed hydrogen sulphide is now passed through this solution. Yellow sulphide of arsenic tinct layer on the top of the yellow sulphide of is first precipitated. White germanium disulphide next appears, and if the liquid is not agitated, this white sulphide separates as a distinct layer on the top of the yellow sulphide of arsenic. When precipitation is complete, the large bottle is stoppered and is allowed to stand for 24 hours. The contents of the bottle is then brought upon a filter and the sulphides are washed with the aid of suction with 3N sulphuric acid that has been saturated with hydrogen sulphide.

The filtrate from the sulphides of germanium and arsenic is placed in a large bottle or in a tall, covered, glass cylinder, and allowed to stand for 48 hours. At the end of this time a slight precipitate of the sulphides separates out. The supernatant liquid is then syphoned off and the bottle or cylinder is filled with the filtrate from the next precipitation, which is again allowed to stand for 48 hours. When a fairly large amount of the sulphides has accumulated in the vessel, it is brought upon a filter and washed as before. The amount of germanium that is recovered by this treatment averages about 2 mgrms. for every litre of filtrate.

From this point forward, two different procedures have been followed. In the first of these the moist sulphides are dissolved in a 50 per cent solution of sodium hydroxide with the aid of heat. Successive portions of the sulphides are added to this solution until a small amount is left undissolved. This is then taken into solution by the addition of a little more of the concentrated solution of sodium hydroxide, and then about 8 grms. of solid sodium hydroxide is added to render the solution strongly alkaline, which facilitates the later oxidation of the arsenic. This solution is then placed in a Pyrex flask, which is provided with a rubber stopper that carries a delivery tube, a separatory funnel, and a glass tube that reaches nearly to the bottom of the flask. This last tube has a wider tube fused to its lower end to avoid stoppage. The flask is placed on an asbestos collar, and is connected with a condenser and a receiver in the manner above described. Washed chlorine is then passed through the liquid in the flask to convert the arsenic to the pentavalent form. When the contents of the flask has been saturated with chlorine, and the apparatus is filled with the gas, the speed of the flow of chlorine is lessened, and concentrated hydrochloric acid is run into the flask through the separatory funnel until the acid is in large excess. The flask is then heated and the germanium tetrachloride is distilled in a slow current of chlorine, the distillation being continued until half of the liquid in the flask has passed over.

The major part of the germanium tetrachloride passes over between 90° and 100°. If the tetrachloride is present in appreciable amount, it will appear in the inner tube of the condenser in oily drops. Instead of collecting the germanium tetrachloride as such from this distillation, some water is placed in the receiver to hydrolyze the compound. The resulting hydrated germanium dioxide is pure white in colour. If any of the oily tertrachloride is seen to collect under the layer of liquid on the bottom of the receiver during the distillation, it is an indication that the concentration of hydrochloric acid in the receiver is so high as to repress the hydrolysis of the germanium tetrachloride. In such case more water is poured into the receiver. When half of the liquid in the flask has passed over, the receiver is removed and a fresh receiver containing some water is put in its place. A volume of concentrated hydrochloric acid, equal to the volume of the liquid that has distilled over is now run into the flask through the separatory funnel, and the distillation is continued. When half of the liquid now in the flask is distilled over, most of the germanium tetrachloride has usually passed into the distillate, but it was found that complete separation of that element as the tetrachloride is effected only by many repetitions of the distillation.

The hydrated germanium dioxide is now collected on a small disc of filter paper supported by a Witt plate in a large funnel and is washed first with dilute sulphuric acid and then with small portions of cold water. It is transferred to an evaporating dish and is dried in an air bath at a temperature of 110°. Photographs of the arc spectra of various portions of this material showed that the germanium dioxide contained traces of sodium, calcium, and iron. Fractional precipitation of a solution of a sample of the dioxide by hydrogen sulphide failed to disclose the presence of arsenic.

Germanium in the filtrate and washings from the hydrolysed germanium dioxide is recovered by precipitation with hydrogen sulphide and set aside for 24 hours. The white germanium disulphide is collected on a filter disc, and is washed with 3N sulphuric acid that has been saturated with hydrogen sulphide. The precipitate is then transferred to an evaporating dish, is moistened with nitric acid (1 : 1), is heated until almost all of the nitric acid has been removed, is again moistened with concentrated nitric acid and heated, and is finally ignited in a crucible. When a fairly large amount of germanium dioxide has thus been recovered from the filtrate and wash water, it is again distilled in chlorine to complete its purification.

To free the germanium dioxide from the traces of impurities noted above, it is dissolved in a slight excess of sodium hydroxide with the aid of heat, the solution is treated with chlorine in the manner above described, hydrochloric acid is

added, and the germanium tetrachloride is again distilled off in a current of chlorine and is hydrolysed as before.

The above method for the separation of germanium and arsenic gives quite satisfactory results in respect to the completeness of the recovery of the germanium, but it is open to the following objections.

The precipitate of the mixed sulphides contains a preponderating amount of arsenious sulphide. This necessitates the use of large quantities of sodium hydroxide, chlorine, and hydrochloric acid, and greatly lengthens the time of treatment with chlorine. Again, the addition of hydrochloric acid to the chlorinated solution of the mixed sulphides in sodium hydroxide reprecipitates a part of the sulphides, and the conversion of the germanium in this precipitate into the volatile germanium tetrachloride by the action of hydrochloric acid and chlorine proceeds very slowly. Furthermore, a large amount of arsenic in the precipitate causes the appearance of some of that element in the distillate even though the current of chlorine through the apparatus is not interrupted during the distillation. This fact necessitates a second precipitation of the sulphides of germanium and arsenic and a redistillation in chlorine in order to free the germanium completely from arsenic.

It is evident that these difficulties would largely be obviated if the greater part of the arsenic could be separated from the germanium before the distillation in chlorine. Preliminary experiments indicated that this separation could be accomplished by roasting the dried sulphides in air, and this led to the development of the second procedure for the treatment of the mixed sulphides, which is as follows:—

If the mixed sulphides of germanium and arsenic are to be roasted, it is, of course, essential that the sulphide precipitate be washed free from chlorides before the roasting to avoid loss of germanium through volatilisation of germanium tetrachloride. To this end the washing of the sulphides with 3N sulphuric acid is continued until the chlorides are completely removed. The absence of chlorides in the wash water is ascertained by adding cadmium nitrate to a portion of the liquid to precipitate the hydrogen sulphide, filtering off the precipitate, and then adding silver nitrate to the filtrate. The washed sulphides are transferred to a large evaporating dish and are dried in an air bath at 110°.

The dried sulphides consist of from 78 to 90 per cent of arsenious sulphide, the remainder being germanium disulphide and moisture, together with small quantities of sulphur and sulphuric acid. These dry, crude sulphides are placed in shallow iron dishes, and are roasted in a muffle furnace at a temperature not to exceed 500°. This removes the greater part of the arsenic. In the roasting of the sulphides, it is important that the temperature does not rise above 500°, for otherwise there will be a loss of germanium. When the roasting was carried on at a temperature somewhat above 600°, about 30 per cent of the germanium was volatilised. At temperatures ranging between 800° and 900°, about 90 per cent of the germanium was lost by volatilisation. That there was no loss of germanium when the roasting was carried on at a temperature not above 500° was ascertained by placing a curved sheet of aluminium above the iron dish in the muffle and subjecting to spectrographic examination the sublimate that collected on it. The roasting is stopped when fumes cease to appear.

Each of three 100-grm. samples of the dried, crude sulphides yielded, on roasting, about 24 grms. of the germaniferous residue. The actual decrease in the amount of arsenic was, however, greater than this difference of weight indicates, because of the formation of a considerable amount of iron oxide during the roasting. The extent of the removal of arsenic was approximately ascertained by determining the amount of arsenic in an unroasted sample and in that sample after roasting. Before roasting, the material contained 78·2 per cent of As_2S_3, and after roasting, 5·52 per cent of arsenic calculated as As_2S_3. These results indicate that somewhat over 90 per cent of the arsenic is removed by this treatment.

The germanium in this residue is extracted by dissolving the finely pulverised material in a 50 per cent solution of sodium hydroxide with the aid of heat. The heating is then stopped and the flask is connected with a condenser and receiver for distillation in the manner previously described. Chlorine is passed through the apparatus until the liquid in the flask is saturated, whereupon the speed of flow of the chlorine is lessened and two parts by weight of concentrated hydrochloric acid to every one part by weight of the roasted residue is next run into the flask through the separatory funnel. Half of the liquid in the flask is distilled over and then an equal volume of concentrated hydrochloric acid is run into the flask and that same volume of distillate is again collected. This usually completely removes the germanium and no more than faint traces of arsenic are found in the distillate. The resulting hydrated germanium dioxide is freed from the last traces of arsenic by dissolving it in sodium hydroxide, chlorinating the solution, and again distilling with hydrochloric acid in a current of chlorine.

This procedure of first roasting the mixed sulphides to remove the greater part of the arsenic and then distilling off the germanium tetrachloride from the residue is superior to the first method of distilling the germanium tetrachloride from the mixed sulphides direct, in that the consumption of materials is less, the time needed for the distillation is much shorter, and the separation from arsenic is more complete. It possesses, however, one drawback, the necessity of washing the mixed sulphides free from chlorides before roasting. If a small sample of the sulphides be washed with 3N sulphuric acid that has been saturated with hydrogen sulphide, chlorides can be removed quite completely and the filtrate is free from detectable amounts of germanium, but it was found that when this method was used on a large scale, repeated washing with 3N sulphuric acid yields eventually a milky filtrate which slowly deposits white germanium sulphide when its acidity is brought up to 6N. 5N sulphuric acid saturated with hydrogen sulphide was substituted for the 3N acid. This gave a clear filtrate from which no appreciable amount of germanium sulphide separated on standing, but the removal of the chlorides was very slow. Attempts to wash the

precipitated sulphides with 5N sulphuric acid by decantation led to no satisfactory results.

Either of the above processes yields a very pure germanium dioxide. The first gives a somewhat higher yield, and the second procedure is considerably shorter. The precipitation of arsenic trisulphide substantially free from germanium sulphide from weakly acid solutions is now being studied in the hope that a procedure superior to either of those above described may be developed.

(To be continued).

CHEMICAL NOTICES FROM FOREIGN SOURCES.

Comptes Rendus Hebdomadaires des Séances de l'Academie des Sciences. Vol. clxxiii., No. 11.

"Induction Spectrum of Rubidium."—By M. Louis Dunoyer.

"*The Inversion of Rotatory Power of Derivatives* of Tartaric Acid."—By M. R. de Mallemann.

"Influence of Temperature on the Utilisation of Glucose for the Development of Aspergillus Niger."—By MM. Emile F. Terroine and René Durmser.

NOTES.

THE *Fuel Economy Review* for August contains an important paper on the "Economics of Coal Production," by Prof. Henry Louis, M.A., D.Sc., A.R.S.M. The writer takes a very serious view of the present situation in the coal industry, and gives much valuable statistical information. With regard to the decrease in production in the coal industry, it is stated that "it is becoming increasingly evident that unless work is to be done in the future in a different spirit to what it has been in the past, the British coal industry is doomed to disappear." This is a statement of very serious import, and it is to be hoped that the different spirit that many are hoping for will soon influence both colliery owners and miners. Contrasted with other countries, British coal costs much more to produce, and we are at the moment surrounded by competitors more favourably circumstanced than we are, a condition that does not seem very hopeful. Our only chance for holding our own is that of greatly increased production, which is quite possible provided the hoped for "new spirit" will come along. Prof. Louis's final conclusion is that an increase in production with a corresponding decrease in selling price is the only means of stimulating the demand and reviving trade, and the essential condition to render this possible is the cheapening of the coal supply. In coal production as in all other branches of our national industries, our needs may be summed up in one phrase: Less "Labour" and more Work!

NEW COMPANIES.

The under-mentioned particulars of New Companies recently registered are taken from the Daily Register compiled by JORDAN & SONS, LIMITED, Company Registration Agents, Chancery Lane, W.C.2.

VITAMINES, LIMITED.—(176740)—Registered September 10th, 1921. To acquire Patents and to Manufacture, Deal in, or otherwise turn to account, Food of all descriptions. Nominal Capital: £1,000 in 20,000 Shares of 1/- each. Directors: E. Ogdew, Belsfield, South Shore, Blackpool; Isabella C. Morgan, 7, Park Street, Swinton. Qualification of Directors: 1 Share. Remuneration of Directors: To be voted by Company in General Meeting.

W. DALBY, LIMITED.—(177641)—Registered September 10th, 1921. 167, Charnwood Street, Leicester. To carry on the business of Chemists and Druggists. Nominal Capital: £1,000 in 1,000 Ordinary Shares of £1 each. Directors: W. Dalby, 167, Charnwood Street, Leicester. K. C. Biggs, 51, Highfield Street, Leicester. Qualification of Directors: 1 Share. Remuneration of Directors: To be voted by Company in General Meeting.

INDUSTRIAL SOAP, CO., LIMITED.—176784)—Registered September 14th, 1921. To carry on the business of Manufacturers and Dealers in Soap, Oils and Oleaginous and Saponaceous substances. Nominal Capital: £10,000 in 10,000 Shares of £1 each. Directors: To be appointed by Subscribers. Qualification of Directors: £100. Remuneration of Directors: To be voted by Company in General Meeting. Subscribers: W. Nichol, 2, Victoria Road, Levenshulme (500 Shares); C. Miller, 41, Albert Road, Levenshulme (500 Shares); J. Miller, Green Mount, 220a, Plymouth Grove, Chorlton-on-Meadlock (500 Shares); F. Bridge, Smithfield Market, Manchester (500 Shares); G. Marsdenam, 8, Market Street, Warrington (300 Shares); H. W. Billam, 7, St. John Street, Manchester (400 Shares).

FLETCHER'S PHARMACY, LIMITED.—(176749)—Registered September 12th, 1921. 166-168, North Street, Leeds. To carry on the business of Chemists and Druggists. Nominal Capital: £500 in 500 Shares of £1 each. Directors: P. Hipps, 50, Kent Road, Harrogate; M. Fletcher, 166-168, North Street, Leeds. Qualification of Directors: 50 Shares. Remuneration of Directors: To be voted by Company.

HARRIS & MORRIS (CHEMISTS), LIMITED.—(176734)—Registered September 10th, 1921. 199a, High Street, Swansea. To carry on *the business of Chemists and Druggists. Nominal Capital*: £500 in 500 Shares of £1 each. Directors: To be appointed by Subscribers. Qualification of Directors: 1 Share. Remuneration of Directors: To be voted by Company.

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EDINBURGH, 1921.

NOTES ON WATER POWER DEVELOPMENT.

ADDRESS DELIVERED BEFORE SECTION G (ENGINEERING)

BY PROFESSOR A. H. GIBSON, D.Sc., President of the Section.

THE extent to which the water powers of the world have been investigated and developed during the past decade forms one of the striking engineering features of the period. Although falling or flowing water formed the earliest of the natural sources of energy to be utilised for industrial purposes, it is of interest to note that two-thirds of the water power at present in use has been developed within the last ten years.

The reasons for the revival of interest in this question are partly technical and partly economic. The technical development of electric generation and transmission has made it economically possible to utilise powers remote from any industrial centre, while a rapid increase in the demand for energy for general industrial purposes and for the many electro-chemical, electro-physical, and electro-metallurgical processes which are now in general use, and whose field is rapidly growing, has provided a ready outlet for all such energy as could be cheaply developed.

The urgent demand for energy to supply the abnormal requirements of the war period, combined with the world shortage of fuel, was responsible for an unprecedented rate of development in most countries with available water power resources, and especially in those countries normally dependent on imported fuel.

Thus in France some 850,000 water horse-power has been put into commission since 1915, and the country now has 1,600,000 horse-power under control as compared with 750,000 before the war. In Switzerland some 600,000 horse-power has been developed since 1914, or is in course of construction, as compared with 880,000 horse-power before the war. In Spain, where the pre-war output was 150,000 horse-power, the present output is 620,000 horse-power, and about 260,000 horse-power is now in course of development, while the Spanish Ministerio de Fomento is considering the development of some 2,000,000 horse-power to be delivered into a network of transmission lines covering the industrial parts of the country.

In Italy, schemes totalling about 300,000 horse-power are under way, and it is estimated that the total output will shortly amount to 2,000,000 horse-power. The Government Hydrographical Department is now engaged in gauging and surveying the profiles of the principal rivers, and statistics of available reservoir sites of lakes suitable for storage and of available horse-power are being compiled.

Japan, which only recently began to investigate her water powers, has, since 1910, developed over 1,000,000 horse-power, or almost 20 per cent of her available resources.

In Canada and the United States many large schemes have recently been brought into service, and some extremely large installations are now in course of construction or are projected. Thus the Queenston-Chippewa project on the Canadian side of the Niagara River is intended to develop some 500,000 horse-power, while a projected development of the St. Lawrence River will be capable of yielding 1,700,000 horse-power. In Canada, the total development (2·3 million horse-power) in 1918 was almost three times as great as in 1910. In the United States of America the development has increased from something under two million horse-power in 1901, to 5·3 millions in 1908, and to nearly 10·0 millions in 1920.

Rapid as has been the development of water power in the United States in the past, it has been retarded by the fact that the privilege of using the national forests or other public lands for water power development has only been granted by the issuing of permits which were not available for any definite period and which were revocable at the will of the Granting Authority. In the case of development on navigable streams, hwether on public or private land, each scheme has required a special Act of Congress, and these Acts could be revoked by Congress at any time. Owing to the uncertainty of tenure there has naturally been some reluctance to invest capital in such undertakings.

By the recent Federal Water Power Act, signed in June, 1920, licences for such developments may now be issued under the jurisdiction of a new body, known as the Federal Power Commission, for a period not exceeding 50 years, at the end of which the licence may be renewed, or the Government may take over the enterprise upon compensation of the licensee. In the issuing of licences, preference is to be given to State and municipal applications. The effect of this Act may be inferred from the fact that, within a month of its being signed, applications for licences to develop over 500,000 horse-power had been filed. The duty of collecting, recording, and publishing data regarding the utilisation of water resources, the water-power industry and its relation to other industries, and regarding the capacity, development costs, and relationship to possible markets, of power sites, has also been assigned to this Federal Power Commission.

World's Available Water Power.—During the past few years much attention has been paid to statistics of available and developed water powers. In the case of developed powers, these are usually stated in terms of the capacity of the installed machinery. This machinery is in general only used to its full capacity over a portion of each day, although in many such cases water is available for providing continuous power if desired.

Estimates of potential power are always to be accepted with considerable reserve. In order to make a reasonably accurate estimate, the run off from the catchment area and the variation in this run off from month to month and from year to

year, must be known, and it is only in comparatively rare cases that this information is as yet available. Moreover, there is as yet no standard basis on which potential power is computed.

The power available from a given stream during the wet season is many times as great as during the dry season, unless sufficient storage is available to equalise the flow throughout the year, and the cost of such storage would in general be prohibitive, even if it were physically possible to provide it.

The United States Geological Survey takes the maximum useful flow of a stream as being that which may be guaranteed during six months in each year. The minimum flow is taken as the average which can be guaranteed over the two driest consecutive seven-day periods in each year, along with the additional flow which may be obtained during this period by developing any available storage capacity in the upper waters of the stream. Estimates of potential power based on storage capacity are, however, subject to a wide margin of error owing to the limited data available, and in the following table the potential water-power is estimated on the basis of the maximum flow as just defined, and in terms of continuous 24-hour power.

Millions of Horse Power.

	Available	Developed
Great Britain … … … … … …	0·9	0·2
Canada … … … … … … …	25·0	3·28*
Remainder of British Empire, including: Australia … …; Africa (East) …; Africa (South) …; Africa (West) …; British Guiana …; India and Ceylon; New Zealand …; Papua … … …	30·0 to 50·0	0·7
Austria … … … … … … …	6·5	0·57
Brazil … … … … … … …	26·0	0·32
Dutch East Indies … … …	5·5	—
France … … … … … … …	5·6	1·6
Germany … … … … … …	1·5	0·75
Iceland … … … … … …	4·0	1·0†
Italy … … … … … … …	4·0	1·25
Japan … … … … … … …	8·0	1·5
Norway … … … … … …	7·5	1·25
Russia … … … … … … …	20·0	1·0
Spain … … … … … … …	5·0	0·88
Sweden … … … … … … …	6·2	1·2
Switzerland … … … … … …	4·0	1·4
United States of America … …	28·0	9·8

* Including projected extensions to plants now in operation.

† Projected but not yet constructed.

Adopting these figures, it appears that the available horse-power of the world is of the order of 200 millions, of which approximately 25 millions is at present developed or is in course of development.

Power Available in Great Britain and in the British Empire.—With the noteworthy exceptions of Canada and New Zealand, practically nothing had been done, prior to 1915, by any part of the British Empire to develop or even systematically to investigate the possibilities of developing its water powers. It is true that a number of large installations had been constructed in India and Tasmania, but their aggregate output was relatively inconsiderable.

Since then, however, there has been a general tendency to initiate such investigations, and at the present time these are being carried out with varying degrees of thoroughness in India, Ceylon, Australia, South and East Africa, and British Guiana. While it is known that there is ample water-power in Newfoundland, Nigeria, Rhodesia, Papua, and the Gold Coast, no very definite information is available, nor are any steps apparenly being taken to obtain data in these countries.

The Water-power Committee of the Conjoint Board of Scientific Societies, which has been studying the state of investigation and development throughout the Empire since 1917, has, however, come to the conclusion that its total available water-power resources are at least equivalent to between 50 and 70 million horse-power.

Of the developed power in the Empire about 80 per cent is in Canada. Throughout the remainder of its territories only about 700,000 horse-power is as yet developed, or only a little over 1 per cent of the power available, a figure which compares with about 24 per cent for the whole of Europe, and 21 per cent for North America, including Canada and the U.S.A. These figures sufficiently indicate the relatively large scope for future development.

Power Available in Great Britain.—With a view of ascertaining the resources of our own islands, *a Board of Trade Water Power Resources Committee* was appointed in 1918. This Committee, which has just presented its final report, has carried out preliminary surveys of as many of the more promising sites as its limited funds allowed, and has obtained data from the Board of Agriculture for Scotland, the Ordnance Survey Department, the Ministry of Munitions, and from civil engineers in private practice, regarding a large number of other sites.

As might be anticipated, Scotland, with its comparatively high rainfall, mountainous area, and natural lochs, possesses relatively greater possibilities than the remainder of the United Kingdom, and investigation has shown that it offers a number of comparatively large schemes. Nine of the more immediately promising of those examined by the Committee have an average output ranging from 7,000 to 40,000 continuous 24-hour horse-power, and an aggregate capacity of 183,000 horse-power, while in every case the estimated cost of construction is such that power could be developed at a cost appreciably less than from a coal-fired station built and operated under present-day conditions. The aggregate output of the Scottish schemes brought before the notice of the Committee, some of which, however, are not commercially feasible at the moment, is roughly 270,000 continuous horse-power.

In addition to these there are a very large number of other small schemes which have not yet been investigated,* and it is probably well within the mark to say that there are water-power sites in the country capable of developing the equivalent of 400,000 continuous horse-power or 1,500,000

* In a paper read before the Royal Society of Arts on January 25, 1918, Mr. A. Newlands, M.I.C.E., gave a list of 122 potential Scottish schemes, the capacity of which he estimated, on a very conservative basis, at 375,000 horse-power.

horse-power over a normal working week, at least as cheaply as from a coal-fired installation.

A number of attractive schemes are also available in North Wales, though these are in general more expensive than those in Scotland.

Owing to the general flatness of the gradients, there are, except possibly around Dartmoor, no schemes of any large individual magnitude in England, but there are a large number of powers ranging from 100 to 1,000 horse-power which might be developed from river flow uncontrolled by storage.

Investigations on a few typical watersheds throughout England and Wales appear to show that the possible output averages approximately eight continuous horse-power per square mile of catchment area, which would be equivalent to an aggregate of about 450,000 horse-power. Although much of this potential output is not commercially feasible, it would give the equivalent of 500,000 horse-power over a normal working week if only 30 per cent of it were fully utilised.

In the report recently issued by the Irish Sub-Committee of the Board of Trade Water Power Committee, it is estimated that approximately 500,000 continuous 24-hour horse-power is commercially available in Ireland, and that if utilised over a 48-hour working week, its capacity would be at least seven times as great as that of the engine power at present installed in the country for industrial purposes.

It appears then that, although the water-power possibilities of the United Kingdom are small in comparison with those of some more favoured countries, they are by no means so negligible as is commonly supposed, even in comparison with the present industrial steam power resources of the country.

The capacity of the fuel power plants installed for industrial and public utility services in the United Kingdom in 1907 was approximately 9·8 million horse-power. Allowing for an increase of 15 per cent since then, and an average load factor of 35 per cent, this is equivalent to 32,000 million horse-power hours per annum, or to a continuous 24-hour output of only 3·7 million horse-power.

According to Sir Dugald Clerk, the average consumption of coal per horse-power hour in this country is about 3·9lb., which, on the above basis, would involve a total annual consumption of 55 million tons for industrial purposes, not including railways or steamships. This figure is in substantial agreement with the estimate of 60 million tons made for factory consumption in 1913 by the Coal Conservation Committee of the Ministry of Reconstruction, since this latter figure also includes coal used for heating and other manufacturing processes in factories.

Adopting this figure of 32,000 million horse-power hours as the annual demand for power for industrial purposes, it appears that the inland water-power resources of the United Kingdom are capable of supplying about 27 per cent of this, a proportion which, in such an industrial country as our own, is somewhat surprisingly large.

Many of the small powers would be well adapted for linking up, as automatic or semi-automatic stations, into a general network of electricity supply, or for augmenting the output of municipal supply works, as has been done so successfully, for example, at Chester, Worcester, and Salisbury.

The development of the many small schemes available in the Scottish Highlands would probably have a great effect on the social life of the community. It would go far towards reviving and extending those small local industries which should form an essential feature of the ideal rural township. Commercially such undertakings may appear to be of small importance, but as a factor in promoting the welfare of the State, economical and political, their influence can hardly be over-estimated.

Some of the larger schemes in Scotland would lend themselves admirably to transmission to its industrial districts, while others, in close vicinity to the sea-board, would appear to be well adapted for supplying chemical, or electro-physical, or metallurgical processes.

There is a probability that at least two of these schemes will be developed in the near future. One of these—the Lochaber scheme—is capable of developing some 72,000 continuous horse-power, which is to be utilised largely in the manufacture of aluminium. It is interesting to note that when this scheme is completed the British Aluminium Corporation will have, with their station at Kinlochleven, an average continuous output of over 100,000 horse-power, and a maximum capacity of almost 140,000 horse-power.

The second—the scheme of the Grampian Power Company—is intended ultimately to develop upwards of 40,000 continuous horse-power, which it is proposed to use largely for general industrial purposes.

Should this latter scheme be carried to a successful conclusion it is likely to give an impetus to large-scale water-power development in Scotland. Its successful operation would certainly lead to the development of others of the same type, which would help to provide a much-needed home training ground for British hydro-electric engineers.

While this is admittedly an inopportune moment to suggest anything in the nature of State co-operation in such developments, it may be pointed out that many of the Scottish powers in particular occur in sparsely-populated districts, and that, although they would ultimately become remunerative, the difficulty of raising the capital necessary for their development is great. In view of their direct and indirect advantage to the community it would appear not unreasonable to advocate that financial assistance should be granted by the State in the earlier stages of such developments. If such assistance, say, in the form of a loan maturing after a period of 10 or 15 years, could be granted, it would certainly give an immediate impetus to the development of water-power in this country.

Conservation.—The importance of water-power development from the point of view of conservation of natural resources requires no emphasis. When the value of coal purely as a chemical asset or as a factor in the manufacture of such materials as iron and steel, cement, &c., is considered, its use as a fuel for power purposes, when any other equally cheap source of energy is available, would appear, indeed, to be unjustifiable.

The consumption of coal in the best modern

steam plant of large size, giving continuous output, would be about nine tons per horse-power year, and on this basis the world's available water-power if utilised would be equivalent to some 1,800,000,000 tons of coal per annum. The world's output of coal in 1913 was approximately 1,200,000,000 tons, of which about 500,000,000 were used for industrial power purposes, so that on this basis 55,000,000 continuous water horse-power would be equivalent to the world's industrial energy at that date.

Not only does the use of water power lead to a direct conservation of fuel resources, but it also serves to a notable degree to conserve man-power. To take an extreme example, each of the 40,000 horse-power units now being installed at Niagara Falls will require for operation two men per shift. It is estimated that to produce the same power from a series of small factory steam plants, over 800 men would be required to mine, hoist, screen, load, transport by rail, unload, and fire under boilers the coal required, while, if account be taken of the additional labour involved in horse transport, wear and tear of roads and of railroad tracks and rolling stock, the number would be considerably increased.

Uses of Hydro-Electric Energy.—While a large proportion of the energy developed from water-power is utilised for industrial purposes and for lighting, power, and traction, an increasing proportion is being used for electro-chemical and electro-metallurgical processes. It is probable, indeed, that we are only on the threshold of developments in electro-chemistry, and that the future demand for energy for such processes will be extremely large.

In Norway the electro-chemical industry absorbed 770,000 horse-power in 1918, or approximately 75 per cent of the total output, as compared with 1,500 horse-power in 1910. Of this, some 400,000 horse-power was utilised in nitrogen fixation alone.

The production of electric steel in the U.S.A. increased from 13,700 tons in 1909 to 24,000 tons in 1914, and 511,000 tons in 1918, this latter quantity absorbing 300 million k.w. hours, equivalent to almost 400,000 continuous horse-power.

In Canada, in 1918, the pulp and paper industry absorbed 450,000 horse-power, or 20 per cent of the total, while the output of central electric stations amounted to 70 per cent of the total.

The electrification, on a large scale, of trunk line railways is also a probability in the not distant future. In the U.S.A., 650 miles of the main line of the Chicago, Milwaukee, and St. Paul Railway, comprising 850 miles of track, have been electrified, the power for operation being obtained from hydro-electric stations. In France much of the track of the Compagnie du Midi in the region of the Pyrenees has been electrified with the aid of water power; much of the Swiss railway system has been electrified; and the electrification of many other trunk lines on the European continent is at present under consideration.

Quite apart from the probable huge demand in the distant future for energy for the manufacture of artificial fertilisers by some system of nitrogen fixation, agriculture would appear to offer a promising field for the use of hydro-electric power.

Much energy is now being utilised in the U.S.A. for purely agricultural purposes. In California, for example, there is in effect one vast system of electrical supply extending over a distance of 800 miles with 7,200 miles of high-tension transmission lines. This is fed from 75 hydro-electric stations, inter-connected with 47 steam plants, to give a total output of 785,000 horse-power. A further group of 13 hydro-electric schemes now under construction will add another 520,000 horse-power. A large proportion of this power is used in agriculture, and a census in 1915 showed that electric motors equivalent to over 190,000 horse-power were installed on Californian farms. The Californian rice industry is almost wholly dependent on irrigation made possible by electric pumping, while most of the mechanical processes involved in farming are being performed by electric power.

There can be little doubt that the economic development of many of our tropical dependencies is bound up in the development of their water-power resources. Not only would this enable railroads to be operated, irrigation schemes to be developed, and mineral deposits to be mined and worked, but it would go far to solve the black labour problem, which promises to be one of some difficulty in the near future.

While those outlets for electrical energy which are now in sight promise to absorb all the energy which can be cheaply developed for many years to come, there are many other probable directions in which cheap energy would find a new and profitable outlet. Among these may be mentioned the purification of municipal water supplies; the sterilisation of sewage; the dehydration of food products; and the preservation of timber.

Scope for Future Water Power Development.—The figures already quoted indicate that the scope for inland water power development throughout the world, and more particularly throughout the British Empire, is likely to be large for many years to come, and it is gratifying to know that British engineers are prepared to play a large part in such development work.

The utilisation of this water power is likely to give rise to some economic problems of interest and importance. When industrial conditions have again become stabilised, the competitive ability of the various nations will depend largely on economy in the application of energy to production and transportation, and the possession of cheap water power is likely largely to counterbalance the possession of such resources as coal and iron as a measure of the industrial capacity of a nation.

While it is probably true in industrial communities that the most attractive water-power schemes have already received attention, many of those available in countries which have hitherto been non-industrial are capable of extremely cheap development and will certainly be utilised as soon as a market for their output can be assured.

It is in such countries that the result of these developments is likely to be most marked, and will require most careful consideration. Thus, the hydro-electric survey of India now being carried out by the Indian Government indicates that very large water power resources are available in the country, and that, although a few large schemes have been or are being developed

the resources of the country are practically untouched. There can be little doubt that in the course of time a large amount of cheap energy will be available in India for use in industrial processes, and as the country possesses a large and prolific population readily trained to mechanical and industrial processes, along with ample supplies of raw material for many such processes, all the conditions would appear to be favourable for its entry into the rank of manufacturing and industrial nations.

Modern Tendencies in Water Power Development.—The large amount of attention which has been concentrated on the various aspects of water power development during the past ten years has been responsible for great modifications and improvements in the design, arrangement, and construction of the plant.

Broadly speaking, these have been in the direction of increasing the size, capacity, reliability, and efficiency of individual units; of improvng the design of the turbine setting and of the head and tail works; of iucreasing the rotative speed of low head turbines; of detailed modifications in the reaction type of turbine to enable it to operate under higher heads than have hitherto been considered feasible; and of increasing the voltage utilised in transmission.

The capacity of individual units has been increased rapidly during recent years, and at the present time units baving a maximum capacity of 55,000 horse-power under a bead of 305ft. are being installed in the Queenston-Chippewa project at Niagara, while units of 100,000 horse-power are projected for an extension of the same plant.

These modern high-power turbines are usually of the vertical shaft, single runner type, with the weight of the shaft, runner, and generator carried from a single thrust bearing of tbe Michell type. This type lends itself to a simple and efficient form of setting, while the friction losses in the turbine are extremely low. As a result of careful overall design it has been found possible to build units of this type having an efficiency of approximately 93 per cent.

One of the great drawbacks of the low head turbine in the past has been its relatively slow speed of rotation, which necessitated either a slow speed, and consequently costly generator, or expensive gearing. As a result of experiment it has, however, been possible so to modify the form of the runner as greatly to increase the speed of rotatiun under a given head without seriously reducing the efficiency.

Investigations in this direction are still in progress and promise to give rise to important results. At the present time, however, turbines are in existence which are capable of working efficiently at speeds at least five times as great as would have been thought feasible ten years ago.

The non-provision of a suitable pipe line has, until recent years, tended to retard the development of plants for very high heads. Under such heads the necessary wall thickness, even with a moderate pipe diameter, becomes too great to permit of the use of riveted joints. Recent developments in electric welding and oxy-acetylene welding have, however, rendered it possihle to construct suitable welded pipes, and by their aid, and by the use of solid drawn steel pipes in extreme cases, it has been found possible to harness some very high falls. The highest as yet utilised is at the Fully installation in Switzerland. Here the working head is 5,412ft., corresponding to a working pressure of 2,360lb. square inch. The pipe line is 19·7in. in diameter, and 1⅛in. thick at its lower end, and each of the three Pelton wheels in the power house develops 3,000 horse-power, with an efficiency of 82 per cent.

Until comparatively recently the Pelton wheel was looked upon as the only practicable turbine for high heads, and the use of the Francis turbine was restricted to heads below about 400ft. This was due partly to the fact that a reaction turbine of compatatively small dimensions gives a large output under a high head, and except in turbines of comparatively large power the water passages become very small, and the friction losses in consequence large.

A further and more important reason for the general choice of the Pelton wheel for high heads was the fact that in the earlier Francis turbines, when operating under heads involving high speeds of water flow, corrosion of the runner was very serious. This corrosion is now generally attributed to the liberation of air containing nascent oxygen, at points where eddy formation causes regions of low pressure. Carefol design of the vanes has enabled this to be largely prevented in modern runners, and in consequence the field of useful application of the Francis turbine has been extended until at present turbines of this type are operating successfully under a head of 850ft., and this limit will probably be exceeded in the near future.

The great increase in all constructional costs, since 1914 has increased the cost of the average hydro-electric plant by something of the order of 150 per cent., and since the cost of energy produced by such a plant is mainly due to fixed charges on the capital expenditure, this cost has gone up in an even greater proportion owing to the higher interest charges now demanded.

It is true that the same increased cost applies within narrow limits to the output from every steam plant erected since the War, and the relative position of the two types of power plant with coal at about 25s. per ton is much the same as before the war.

The fact remains, however, that a newly-constructed hydro-electric plant has often to compete in the market with a steam plant built in pre-war whose standing charges are comparatively low, and in order to enable it to do so with success the constructional cost must often be reduced to a minimum compatihle with safe and efficient operation. With this in view, many modifications in design and construction have been introduced in recent plants, but there would still appear to be ample scope for investigation into the possibility of reducing the first cost by modifying many of the details of design and methods of construction now in common use.

Among recent modifications in this direction may be mentioned :—

(1) The elimination of the dam in storage schemes in which natural lochs or reservoirs are utilised, this water level being drawn down in times of drought instead of being raised in times of flood. This

reduces the cost of construction appreciably in favourable circumstances, and eliminates the necessity for paying compensation for flooding of the land surrounding the reservoir.

(2) The substitution, where feasible, of rockfill dams for those of masonry or monolithic concrete.

(3) The introduction of outdoor installations with the minimum of power house construction.

(4) The simplification of the power plant.

Some progress has already been made in these directions, and it is probable that experience based on recent installations and experimental investigations will enable considerable further progress to be made.

Research in Hydro-Electric Problems.—There are few branches of engineering in which research is more urgently required and in which it might be more directly useful.

Among the many questions still requiring investigation on the civil and mechanical side may be mentioned :—

(1) *Turbines.*—Investigation of turbine corrosion as affected by the material and shape of the vanes.

Effect of erosion due to sand and silt.

Resistance to erosion offered by different materials and coatings.

Bucket design in low head high-speed turbines.

Draft tube design.

Investigation of the directions and velocities of flow in modern types of high-speed turbines.

Investigation of the degree of guidance as affected by the number of guide and runner vanes.

(2) *Conduits and Pressure Tunnels.*—The design of large pipe lines under low heads with the view of reducing the weight of metal. The investigation of anti-corrosive coatings, so as to reduce the necessity for additional wall thickness to allow for corrosion.

Methods of strengthening large thin-walled pipes against bending and against external pressures.

Methods of lining open canals and of boring and lining pressure tunnels.

Effects of curvature in a canal or tunnel.

(3) *Dams.*—Most efficient methods of construction and best form of section especially for rockfill and earthen dams. Best methods of producing water tightness.

(4) *Run-off Data.*—Since the possibility of designing an installation to develop the available power efficiently and economically depends in many cases essentially on the accuracy of the run-off data available, the possession of acurate data extending over a long series of years is of great value.

While such data may be obtained either from stream gaugings or from rainfall and evaporation records, the former method is by far the more reliable. For a reasonable degree of accuracy, however, records must be available extending over a long period of years, and at the present moment such data is available only in very few cases.

(To be continued).

GERMANIUM.*

I.—Occurrence; Extraction from Germanium-bearing Zinc Oxide; Non-Occurrence in Samarskite.

By L. M. DENNIS and JACOB PAPISH.

(Concluded from p. 196).

(C) *The Determination of Germanium.*

To gauge the efficiency of the extraction of the germanium from the crude material it was necessary to develop a method for the quantitative determination of germanium. The procedure that was finally adopted is based directly upon the method of extraction that has already been described.

A weighed quantity of the germaniferous zinc oxide that had been dried at 110°, varying in amount from 20 to 100 grms., is ground into a paste with water, and is then poured into a flask that contains a solution of sodium hydroxide. These three substances are used in the proportions of one part of sodium hydroxide, two parts of the crude zinc oxide, and five parts of water. The flask is provided with a three-hole rubber stopper, through which are inserted a glass tube that reaches almost to the bottom of the flask, a small Vigreux distilling column, and a small separatory funnel. To the side arm of the Vigreux tube is fused a Liebig condenser, and a glass adapter is fused to the further end of the condenser. The receiver consists of an Erlenmeyer flask that is provided with a two-hole rubber stopper. Through one of these holes passes the glass adapter, which reaches to within a few millimetres of the bottom of the flask. A delivery tube is inserted through the other hole of the stopper, and this tube is connected with a second Erlenmeyer flask. Water is placed in the first Erlenmeyer flask to a depth of 3 cm., and the second flask is half filled with water. The second flask serves as a check upon the completeness of the condensation of germanium chloride in the first receiver. If any germanium is later found to have passed into the second flask, the determination is rejected. Both of the flasks are placed in a trough containing ice water.

In beginning the distillation, a dish containing cracked ice is brought up under the distilling flask and a slow current of washed chlorine is passed into the flask through the glass tube. As soon as the apparatus fills with chlorine, which indicates that the contents of the flask has been saturated with the gas, pure, concentrated hydrochloric acid is slowly introduced through the separatory funnel. The acid that is eventually added is sufficient to neutralize the sodium hydroxide that was originally employed, and in addition, to equal twice the weight of the crude zinc oxide that is being used. The passage of chlorine and the cooling of the flask are continued during the addition of the acid. When all of the acid has been introduced, the dish of cracked ice is replaced by an asbestos collar and the contents of the flask is then heated in the manner already described. When one-half of the liquid has distilled over, an equal volume of concentrated hydro-

*Contribution from the Department of Chemistry of Cornell University. This article is based upon a part of the thesis presented to the Faculty of the Graduate School of Cornell University by Jacob Papish in partial fulfilment of the requirements for the degree of Doctor of Philosophy.

chloric acid is run into the flask and the distillation is continued until half of the liquid has again passed over. The addition of hydrochloric acid and distillation of one-half of the liquid are once more repeated. The heating is then stopped and the two receivers disconnected. Sulphuric acid is added to the contents of each to bring the acidity to 6N, the flasks standing in ice during the addition of the acid. The liquid in each flask is then saturated with hydrogen sulphide, and the flasks are stoppered and set aside for 24 hours. If the passage of the chlorine through the apparatus during the distillation has been slow, and if the receivers have been kept well cooled with ice, no germanium tetrachloride will pass over into the second receiver. A precipitate will, however, appear in the second flask, because of the liberation of sulphur through the interaction of chlorine and hydrogen sulphide. This precipitate is tested spectrographically to ascertain whether it is free from germanium. If it is not, the determination is rejected. The precipitated germanium disulphide in the first flask is brought upon an ashless filter paper and the small amount of precipitate that adheres to the walls of the flask is loosened by means of a rubber "policeman" and brought upon the filter by rinsing with 3N sulphuric acid that has been saturated with hydrogen sulphide. The whole precipitate is now washed with this liquid until the chlorides are removed. The germanium disulphide is then washed with alcohol to remove the sulphuric acid and is next dried. The bulk of the precipitate is removed from the filter and placed in a weighed porcelain crucible. It is is moistened with nitric acid (1 : 1) and the crucible is gently heated until the liquid has been driven off. The crucible is then allowed to cool, and concentrated nitric acid is added. This is also driven off by gentle heating, and the crucible is then heated to dull redness.

Germanium dioxide that has been dried at 110° still contains an appreciable amount of water. Experiments performed in this laboratory by Miss K. M. Tressler, which will be described in a later article, have shown that complete dehydration is secured only when the dioxide is heated to 900°.

The filter paper is incinerated over a second weighed crucible. The product is black, due to the formation of some germanous oxide caused by the reduction of the germanium dioxide by the carbon of the paper. This is oxidised to the dioxide by treatment with nitric acid.

The filtrate from the precipitation of the germanium disulphide is set aside for 48 hours and the precipitate that then appears is treated in the same manner as the first precipitate. The sum of the weight of the dioxide in the two crucibles less the weight of the ash of the two filter papers gives the weight of germanium calculated as dioxide that is present in the original sample.

Although no great accuracy is claimed for the method as thus far developed, two determinations in duplicate of the germanium in different samples of the crude zinc oxide gave concordant results:—

Sample I.

	I	II
Weight of sample ...	50 grms.	75 grms.
GeO_2 found	0·1235 grms.	0·1860 grms.
Per cent GeO_2 ...	0·247	0·248

Sample II.

	I	II
Weight of sample ...	50 grms.	100 grms.
GeO_2 found	0·0950 grms.	0·1885 grms.
Per cent GeO_2 ...	0·19	0·188

The completeness of the recovery of germanium from the crude zinc oxide by the method of extraction above described is evidenced by the fact that from a series of runs in which a total of about 10·7 kilogrms. of Sample I. of the undried crude oxide was used, 25·936 grms. of pure GeO_2 was obtained.

The Non-Occurrence of Germanium in Samarskite.

Above reference was made to the statement of Khrushchov that he had found germanium in American samarskite. This statement was published in the form of a report in the *Journal of the Russian Physical-Chemical Society.* (We are indebted to the Library of Congress for a pen copy of this report. The translation here given was made by one of us.—J. P.). Literally translated, it reads as follows:—

"K. D. Khrushchov reports about finding germanium in columbium and tantalum minerals. American samarskite was heated in a 300-grm. platinum crucible for the purpose of comminuting the samarskite. After three heatings, the platinum was altered to such an extent that the crucible crumbled to a powder. On dissolving the platinum, a residue was obtained which resembled silica, but it was fairly difficultly soluble in hydrofluoric acid. Assuming the gelatinous sediment to be a germanium dioxide, the reporter found that it was changed very easily by hydrogen to the black powder of germanium. Traces of germanium were also found in tantalite, fergusonite, columbite, gadolinite, and in other minerals. American samarskite contains up to 1·5 per cent germanium. In view of the rarity of argyrodite, the reporter calls attention to samarskite as an important source of germanium."

Lincio (*loc. cit.*) failed to find evidence of the presence of germanium in samarskite. After the method for determining germanium that has been described in the preceding pages had been developed, the question of the occurrence of the element in American samarskite was taken up in this laboratory. 200 grms. of finely-ground selected samarskite was fused with 1200 grms. of primary potassium sulphate. The fused mass was extracted with water, and the residue, which contained a small quantity of undecomposed samarskite, was mixed with more primary potassium sulphate and was fused and extracted with water as before. The two water extracts were combined and were evaporated to dryness.

The insoluble residue from the fusion was moistened with nitric acid, and was then introduced into a Pyrex flask of 500 cc. capacity. 200 cc. of hydrochloric acid was added, and the mixture was subjected to distillation until 150 cc. of distillate had passed over. The distillate was saturated with hydrogen sulphide, and was allowed to stand for 24 hours. The very slight precipitate that formed was collected on a small filter and was dried. The photograph of the arc spectrum of this material failed to show the presence of germanium.

The residue obtained for the water extracts of

the fusion was moistened with nitric acid, and was introduced into a flask of 3-litre capacity. 1500 cc. of concentrated hydrochloric acid was added, and the mixture was distilled until about 600 cc. had passed over. 500 cc. of hydrochloric acid was then run into the flask, and a second distillate of 400 cc. was obtainned. The two distillates were united, were saturated with hydrogen sulphide, and were allowed to stand for 24 hours. The slight precipitate that separated showed no spectrographic evidence of the presence of germanium.

Khrushchov's report is by no means convincing. He obtained a gelatinous residue which he assumed to be germanium dioxide, but he gives no reasons for this assumption, and it is difficult to imagine what his reasons might have been. The fact that the material was darkened when heated in hydrogen might indicate the presence of a variety of compounds other than germanium dioxide. Moreover, it is probable that when he dissolved the platinum, he used aqua-regia for this purpose. If he did so, all of the germanium would probably have been lost through volatilisation of the germanium tetrachloride. It seems evident, therefore, that Khrushchov's experimental work does not justify his statement that samarskite contains germanium, and the results obtained by Lincio and in this laboratory would seem to show that that mineral does not carry detectable amounts of the element.

Summary.

This article contains:—

A brief historical review of the discovery of germanium.

A *resumé* of the published announcements concerning the occurrence of the element.

The details of an experimental study of the extraction of germanium from germanium-bearing zinc oxide, and the preparation of pure germanium dioxide.

Description of a method for the determination of germanium.

The details of an examination of American samarskite which showed that the mineral does not contain germanium in an amount detectable by means of the spectroscope.

Ithaca, N.Y.

LATENT HEAT OF VAPORISATION.

By J. C. THOMPSON.

THE latent heat of vaporization of a liquid

$$=\frac{P \log_{10} P}{10{\cdot}31 \times D^{\frac{1}{3}}}$$

Where P is the density of the substance compared with its vapour density at boiling point.

Where D is the density of the substance as liquid at its boiling point compared with water at 4°C.

The following table will show this:—

Substance	D.	P*	$\frac{P \operatorname{Log} P}{10{\cdot}31 \times D^{\frac{1}{3}}}$	Latent* Heat.
Water ...	0·9856	1629	536·6	536·6
Ethyl Ether	0·736	250·2	87·58	87·4
Benfene ...	0·82	203·5	95·21	96·1
Oxygen ...	1·124	261	52·3	52

*Calculated from molecular weights and 0·3665 coefficient of expansion of gases from 0 to 100°C. 1000 cc of H = 0·089610 grms.

Theoretical determination of above Formula.

Water at 100°C exists in two states the density as liquid being 1629 times the density of gas. The work required to compress a perfect gas from 1 atmosphere to 1629 atmospheres or make its density 1629 times as great is a definite and readily calculated amount. This amount might be expected to bear some relationship to the latent heat of water measured as work. Such a relationsbip does exist. The latent heat multiplied by cube root of the density as liquid is a constant times this work. The cube root of the density of a substance varies as the square root of attractive force between the molecules. When heat goes into a liquid to vaporize it, the heat must do work against the forces of attraction of the molecules. The amount of work that has to be done would be expected to vary directly as the magnitude of the forces of attraction between molecules.

To calculate the work required to compress 1629 cc of gas at 1 atmosphe e to 1 cc of gas at 1629 atmosphere.

Consider first a cylinder of 1 sq. cm. cross section and 1629 cm long. The cylinder placed vertically, sealed at lower end and a movable piston at upper end.

Now if a weight be placed on the piston, the piston will sink, compressing the gas. The work done to produce this compression will be product of weight applied and distance through which weight has moved. If, now, a further weight is added, further compression and further work is done.

Consider, now, the reverse of this, namely, the whole of the weight applied, and successive removals of the weight. That is, a number of weights varying in size from 1629 to 1 atmosphere through a distance up to 1629 cm.

Consider a liquid at its boiling point.

Let P atmospheres = pressure to which an equal volume of gas would be subjected.

Let S atmospheres = its pressure as gas.

Let 1 volume of liquid be taken.

Then this will form $\frac{P}{S}$ volumes of gas.

Then work required to convert 1 volume at P to $\frac{P}{S}$ volumes at S = sum of the products of the pressures at the various volumes from 1 to $\frac{P}{S}$ and the increase in volumes at the various volumes.

Original volume = 1.

Original pressure = P.

Let pressure be first decreased by x, that is, made $P - x$.

The new volume $= \frac{P}{P - x}$

Let pressure next be made $\frac{(P - x)^2}{P}$

Then new volume $= \frac{P^2}{(P - x)^2}$

Let pressure next be made $\frac{(P - x)^3}{P^2}$ &c.

Work = increase in volume × pressure at volume, that is:—

$$\text{Work} = \left(\frac{P}{P-x} - 1\right)(P - x) + \left(\frac{P^2}{(P-x)^2} - \frac{P}{(P-x)}\right)\frac{(P-x)^2}{P} + \&c.$$

$$= \left(\frac{P - P + x}{P - x}\right)(P - x) + \left(\frac{P^2 - P(P-x)}{(P-x)^2}\right)\frac{(P-x)^2}{P} + \&c.$$

$$= x + x + x, \&c.$$

$$= nx \text{ (where } n \text{ is the number of terms).}$$

But $\frac{P^n}{(P-x)^n}=\frac{P}{S}$

$\therefore\ n\log P - n\log(P-x) = \log P - \log S$

$$n=\frac{\log P-\log S}{\log P-\log(P-x)}$$

$$\therefore\ \text{work}=nx=\frac{x(\log P-\log S)}{\log P-\log(P-x)}$$

when x is small this is convertible into the form

$\text{work}=nx=-P(\log_e P-\log_e S)$

or when S = 1 atmosphere

work $=-P\log_e P$ *atmospheres (See note).*

If original pressure was measured in atmospheres and 1 cc. of water was taken.

Work = 1629 $\log_e$ 1629 atmosphere centimetre grams converting into ergs.

Work = 1629 $\log_e 1629\times 76$ cm. $\times 13{\cdot}5959 \times 981$

(76 cm.: Atmospheric pressure; 13·5959: Density of mercury; 981: Acceleration of gravity)

$=1{\cdot}221\times 10^{10}$ ergs.

Latent heat of 1 grm. of water $=536{\cdot}6\times 4{\cdot}188\times 10^7$ ergs.

Latent heat of 1 cc. of water $=536{\cdot}6\times 4{\cdot}188\times 10^7\times 0{\cdot}9586$ ergs.

$=2{\cdot}155\times 10^{10}$ ergs.

Multiplying this last figure by $0{\cdot}5746\sqrt[3]{\text{Density}}$ and treating other substances in a similar manner.

Substance	$P\log_e P$ in Ergs.	Latent Heat	Density	Latent Heat $\times 0{\cdot}5746\sqrt[3]{D}$
Water	$1{\cdot}221\times10^{10}$	$2{\cdot}155\times10^{10}$	0·9586	$1{\cdot}221\times10^{10}$
Ethyl Ether	$0{\cdot}1401\times10^{10}$	$0{\cdot}2695\times10^{10}$	0·736	$0{\cdot}1397\times10^{10}$
Benzene	$0{\cdot}1758\times10^{10}$	$0{\cdot}3300\times10^{10}$	0·82	$0{\cdot}1775\times10^{10}$
Oxygen	$0{\cdot}1472\times10^{10}$	$0{\cdot}2447\times10^{10}$	1·124	$0{\cdot}1462\times10^{10}$

This gives an agreement between the first and last columns equal to this accuracy of data used.

From this:—

$P\log_e P$ = Latent Heat × Density × $\sqrt[3]{\text{Density}}$ × constant.

or $P\log_{10}P$ = Latent Heat × Density$^{4/3}$ × constant.

When Latent Heat is measured to 1 grm. of substance

$$\text{Latent Heat}=\frac{P\log_{10}P}{D^{4/3}}\times\text{constant}$$

$$=\frac{P\log_{10}P}{10{\cdot}31\,D^{4/3}}$$

Relationship between Attractive Forces and Density.

There are a number of assumptions made here which are contrary to accepted theory of matter.

(1) Molecules do not collide but pass sufficiently near to each other for the forces of attraction between them to be constantly altering the directions of movement of the molecules. The forces of attraction probably consist of ordinary gravitational force together with surplus or unsaturated valency force.

(2) Molecules are without size.

(3) *A liquid is merely a gas under the pressure* produced by the attractive forces of its molecules.

(4) A solid is a liquid in which the attractive forces of the molecules are different in different directions.

(5) A crystalline solid is a solid in which the major attractive forces are all acting in one direction, and minor forces all acting in another, etc.

Measurement of the forces of attraction of different substances.

The kinetic energy of a molecule, whether it exists as a gas or liquid, is the same at any one temperature.

Consider the molecules as having kinetic energies which are constantly being reduced to nothing by the attractive forces, and afterwards having their kinetic energy restored. This is analogous to the action of the attractive forces of the sun on a comet, the kinetic *energy of comet relatively to the sun being periodically* reduced to nothing.

The mean kinetic energy of molecules will vary as the ratio of the weights of the molecules to the square of distance between them. That is, attractive forces between equal weights of molecules will vary as the square of distance between the equal weights.

Now the volume occupied by equal weights of a substance will vary as the density of the substances or the distance between equal weights will vary as cube root of density.

But forces of attraction vary as square of distance between the bodies.

That is the sum of all attractive forces of a volume of substance will vary as the two-third root of its density.

It must be noted that the attractive pressure of a substance (that is, the pressure at the surface of a substance) is not the same as the attractive force between the molecules. Neither is the one directly proportional to the other. The attractive pressure is P, which varies as $\frac{D}{M\times T}$

Where D = density as liquid
Where M = molecular weight
Where T = temperature of measurement

T becomes boiling point when measurements are made at the boiling points. P = the density of liquid compared with its density as vapour.

Attractive force varies as $(D^{1/3})^2$. That is as the square of distance between equal weights of substance.

Work required to overcome a force of attraction will vary as that force.

The work $P\log_e P$ is done on vaporisation by the kinetic energy of the molecules. The work of overcoming the attraction of the molecules is done by the latent heat. They both have to be done to the same quantity of material through the same distance. In order to find the latent heat $D^{2/3}$ must be substituted *for D in the expression* $\frac{D}{M\times T}$

Now in the expression $P\log_e P$, P represents the weight and $\log_e P$ the distance through which it is moved, so that $D^{2/3}$, instead of D, has only to be introduced into the P part of the expression $P\log_e P$. Since P contains D the expression becomes

$$\frac{P}{D^{1/3}}\log_e P\times\text{constant}.$$

Determination of constant 0·5746.

The unit of density is 1 grm. of substance occupying 1 cubic centimetre. To divide space into cubic centimetres is not the most economical method hence the ratio of weight of substance to distance between weights is not as 1 grm. is to 1 cm. when density is 1. If, however, we put 1 grm. into the smallest space so that the centre of that space is always a centimetre from the centre of any neighbouring similar space then we have ratio of the weight of substance to the distance between the weights is as 1 grm. is to 1 cm. Now this space under these conditions must be greater than the volume occupied by a sphere of 1 cm. diameter since there would be loss of space between the spheres. It must also be less than the volume occupied by a hexagonal prism of 1 cm. between parallel sides and $\frac{\sqrt{2}}{\sqrt{3}}$ cm. height. Note that $\frac{\sqrt{2}}{\sqrt{3}}$ for height of hexagon is obtained when the hexagons in

layers of hexagonal prisms are not immediately above each other. The value of first $= \frac{\pi}{6}$ cubic cm. $= 0{\cdot}5236$ the value of second $\frac{1}{2}\sqrt{2} = 0{\cdot}707$ cubic centimetres. The required volume must lie between these two and probably be nearer the latter.

If the densities of substances are compared with a substance not of density 1 grm. to 1 cc. but of 1 grm. to 0·6601 cc. then we can eliminate the constant 0·5746. Calling the density of a substance to this δ Latent Heat of 1 grm. $= \frac{P \log_e P}{\delta^{\frac{1}{3}}}$

Latent Heat of 1 grm. $= \frac{P \log_e P}{\delta^{\frac{1}{3}}}$ atmosphere centimetre grms.

CORRESPONDENCE.

GREAT NORTHERN CENTRAL HOSPITAL.

To the Editor of the Chemical News.

SIR,—The Lord Mayor has kindly allowed a meeting on behalf of the Great Northern Central Hospital, Holloway, to be arranged at the Mansion House, on the Eve of St. Luke's Day, *October 17*, at 3 p.m., in order to provide an opportunity of making known more widely the immense value to the Metropolis particularly, and the Nation generally, of the Institution's indispensable work; and in the hope that it may be a means of securing for the hospital the help which it needs so desperately at this critical time.

If the Hospital, which serves a large and densely populated area, with a million residents, is to continue without curtailing its work, it must have at least £22,000 before December 31, in addition to any income it can definitely expect to receive. It is to help in raising this sum that the Lord Mayor has so kindly allowed the meeting to be held.

Distinguished speakers will advocate the claims of the Hospital, and I do hope your readers will give their support, and if they cannot come to the to the meeting send a remittance, no matter how small, to me at the Hospital, so that an efficient hospital service in North London may continue.—I am, &c.,

NORTHAMPTON (*Chairman*).

NOTES.

"OERTLING" BALANCES.—Sir Ernest Shackleton has taken an "Oertling" Balance with him on the *Quest*. An "Oertling" Balance was also taken by Admiral Sir George Nares on his expedition in 1873, and the same balance was used by the late Captain Scott in his expedition in 1901, and during the war it was used by the Engineering Department of the South Kensington Museum. It speaks well for the reliability of an instrument which can be of service 50 years after the date of its manufacture.

WE have received a copy of a new publication, *La France*, a journal that cannot fail to be of interest, especially to students and those wishing for a closer acquaintance with French and French every-day life. It will be published weekly, and give a general review of the daily, weekly, and monthly press. The paper can be obtained from any London newsagent, price 2d., or 2s. 6d. for a period of 17 weeks. The London address is Montague House, Russell Square, W.C.1.

DEVELOPMENT OF BRITISH INDIAN SUGAR INDUSTRY.—According to the Secretary of the Sugar Bureau at Pusa, states *Capital* (Calcutta), India has an annual consumption of 748,544 tons of foreign sugar, and is capable of finding over 15 crores of rupees yearly to meet her additional sugar purchases from abroad. As the price of sugar began to fall in September, 1920, a distinct tendency to import more became evident, despite the extra duty imposed As India's production of refined sugar is at present only 177,569 tons, it is obvious that there is ample scope for many times the number of factories now working in India. The prospect before the Indian sugar industry is very hopeful, as it can choose the most favourable parts of the country for supply for many years to come, and with the increased duty on foreign sugar, coupled with heavier freight and handling charges, it is considered that it would be well if capitalists devoted their time and attention more and more to developing the industry on a sound and scientific basis. There is ample scope and the rise in the cost of production through out the world, both of raw material and the finished product, has told heavily in India's favour.

"JOURNAL OF INDIAN INDUSTRIES AND LABOUR."—Part III. contains a fully illustrated description of the Government Acetone Factory by Mr. A. Appleyard, showing that a deal of good work has been and is being done at Nasik. A very interesting paper is given on "Indian Precious Stone" by Cyril Fox, Curator, Geological Survey of India. Crude alkali, which is plentiful in India, is being used with some success in the manufacture of a fair quality glass for bangles, &c., and a good account is given of the collection and refining of the salts of soda for this purpose by J. P. Srivastava and D. Sinha. There are many other interesting notes of more local interest.

A NEW PUBLICATION DEVOTED TO RADIOLOGY AND RADIOTHERAPY.—*Acta Radiologica*, published by the Societies for medical radiology in Denmark, Finland, Norway, and Sweden, contains articles pertaining to roentgenology, radium therapy, ligbt therapy, and electrotherapy. These articles are published in English, French, or German, according to the decision of the author. Each volume comprises 500 pages, distributed in four occasional numbers. Subscriptions may be forwarded to the Editor. Subscriptions from America may also be sent to Mr. Paul B. Hoeber, 67—69 East 59th Street, New York Cy. Subscription to Vol. I, $6—32s. The work is fully illustrated with half-tone reproductions, and the first number contains the following articles: Editorial; "L'examen radiologique de l'ulcère du duodenum," by H. J. Panner; "The X-ray Diagnosis of Gallstones in the Common Duct," by M. Simon; "Ein Fall von Osteogenesis imperfecta mit verbreiteten Gefässverkalkungen," by Sven Johansson; "A Case of Arthropatia Psoriatica," by S. Ström; "Hemophilia and Hemophilic Arthropathy," by T. Klason; "A Case of Frac-

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ture *of the Cranium with Accumulation of Air in* the Cranial Cavity," by N. Hansson; "A Plate-holder for Precise Roentgenography in Connection with Fluoroscopy," by Gösta Forssell; "*Microscopic Examination of the Mucous Membrane of* the Nose on Patients under Treatment for Lupus Vulgaris with Universal Arc-Light Baths," by K. A. Heiberg and Ove Strandberg; "*Plastic Means of Application and their Use in Radiumtherapy,*" by Lars Edling; "Die Intensitätsverteilung der primären Gamma-strahlung in der Nähe medizinischer Radiumpräparate," by Rolf M. Sievert.

NEW COMPANIES.

The under-mentioned particulars of New Companies recently registered are taken from the Daily Register compiled by *Jordan & Sons, Limited, Company Registration Agents, Chancery Lane, W.C.2.*

VICTOR H. IDDON, LIMITED.—(177042)—Registered September 29th, 1921. 309, Holderness Road, Hull. To acquire and carry on the business of Vendor of Pharmaceutical requirements and Sundries. *Nominal Capital: £1,500 in 1,500 Shares of £1 each.* Directors: V. H. Iddon, 14, The Oval, Garden Village, Hull (Managing Director); E. H. Russell, 14, Village Road, Hull (Managing Director). Qualification of Directors: £50. Remuneration of Directors: To be voted by Company.

FRESSONS DRUG STORES, LIMITED.—(177033)—Registered September 29th, 1921. 177, The Broadway, Cricklewood, Middlesex. To acquire and take over as a going concern and carry on the business of a Drug Store, now carried on by Charles Francis Fresson, at 177, The Broadway, Cricklewood. Nominal Capital: £1,500 in 1,500 Ordinary Shares of £1 each. Directors: C. F. Fresson, *177, The Broadway, Cricklewood, N.W.2. Herminia M. Fresson,* 177, The Broadway, Cricklewood, N.W.2. Qualification of Directors: £10. Remuneration of Directors: To be voted by Company.

CARMOL, LIMITED.—(176775)—Registered September 14th, 1921. 181, High Street, Blackheath, Birmingham. To carry on the business of Chemists and Druggists, etc. Nominal Capital: £1,000 in 1,000 Shares of £1 each. Directors: A. S. Price, 181, High Street, Blackheath, Birmingham; R. T. Tiplady, 12, Bowkers-Row, Bolton (Governing Directors). Qualification of Directors: 25 Shares. Governing Directors: £50 each.

New Patents.

THIS List is specially compiled for the *Chemical News* by Messrs. Rayner & Co., Registered Patent Agents, of 5, Chancery Lane, London, W.C.2., from whom all information relating to Patents, Trade Marks and Designs can be obtained gratuitously.

Latest Patent Applications.

24203—Archer, M. W.—Method of producing white commercially pure ammonium chloride. September 12th.
24415—Fairweather, H. G. C.—Recovery of nitrate from caliche. September 14th.
24658—Jones, H. Sefton.—Manufacture of pure nickel. September 16th.
24670—Perkins, W. G.—Treatment of copper ores. September 16th.
24456—Rodd, E. H.—Manufacture of dye-stuffs. September 14th.
24392—Plauson, H.—Process for treatment of rock phosphate, etc. September 14th.
25298—Akt. Ges. fur Anilin-Fabrikation.—Manufacture of dye-stuffs of the acridine series. September 23.
24872—Brothers, W.—Manufacture of sulphate of aluminium. September 20th.
24831—Lancaster, H. C.—Treatment of antimonial lead. September 19th.
24799—National Aniline & Chemical Co., Ltd.—Seal for containers. September 19th.
25219—Plausons (Parent Co.), Ltd.—Manufacture of colloidal sulphur. September 23.

Specifications published this Week.

168627—Eustis, A. H.—*Method of and apparatus for the recovery of* sulphur dioxide from furnace gases and other gases containing the same.
146939—Trent, W. E.—Method and apparatus for treating ores, chemicals, minerals and the like.
143872—Union Carbide Co.—Manufacture of calcium carbide.
150734—Pfannenschmidt, P. L.—Acid chambers, acid towers, acid mains and similar arrangements.
154888—Hartner, F.—Process for manufacturing a mortar forming material from anhydrite or the like.
161922—Riedel Akt. Ges., J. D.—Soluble mercury compounds.
145038—Johnson, J. Y.—Process for transforming ammonia into a salt for use as a fertilizer.
146289—Carpmael, W.—Manufacture of cynamide derivatives of alpha-halogenated acids.
146410—Clerc, A. and Nohoul, A.—Manufacture of zinc sulphide.
248242—Chemische Fabrik Rhenania and Vorkelius, Dr. G. A.—Manufacture of manures by breaking up phosphates with nitric acid.

Abstract Published this Week.

Chromium Oxide Sodium Sulphide.—Patent No. 166289.—A new process for obtaining chromium oxide and sodium sulphide has been Patented by Mr. C. J. Head, of Norfolk House, Laurence Pountney Hill, London. The products are obtained by heating under reducing conditions a mixture of sodium chromate, sulphur *and carbon in the proportions of* $2Na_2CrO_4$ *2S and 5C.* The product is leached, the chromium oxide being washed, dried and calcined. The sodium sulphide solution may be evaporated to dryness. According to the Provisional Specification, the chromium oxide may be further purified by digesting with sodium carbonate solution, washing with hot water and drying.

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BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

EDINBURGH, 1921.

NOTES ON WATER POWER DEVELOPMENT.

ADDRESS DELIVERED BEFORE SECTION G (ENGINEERING)

By PROFESSOR A. H. GIBSON, D.Sc., President of the Section.

(Concluded from p. 202).

WHERE accurate rainfall and evaporation records are available, it is possible to obtain what is often a sufficiently close approximation to the run off, but even rainfall records are not generally at hand where they are most required, and even in a district where such records are available, they are usually confined to easily accessible points, and are seldom extended to the higher levels of a catchment area where the rainfall is greatest. Even throughout the United Kingdom our knowledge of the rainfall at elevations exceeding 500ft. is not satisfactory, and little definite is known concerning that at elevations exceeding 1,000ft.

In this country evaporation may account for between 20 and 50 per cent of the annual rainfall, depending on the physical characteristics of the site, its exposure, mean temperature, and the type of surface covering. In some countries, evaporation may account for anything up to 100 per cent of the rainfall. As yet, however, few records are available as to the effect of the many variables involved. An investigation devoted to the question of evaporation from water surfaces, and from surfaces covered with bare soil and with various crops, under different conditions of wind, exposure, and mean temperature, would appear to be urgently needed. If this could be combined with an extension of Vermeulle's investigation into the relationship between rainfall, evaporation, and run-off on watersheds of a few characteristic types, it would do much towards enabling an accurate estimate of the water power possibilities of any given site to be predetermined.

Even more useful results would follow the initiation of a systematic scheme of gauging applied to all streams affording potential power sites.

Among other questions which are ripe for investigation may be mentioned :—

(1) The combined operation of steam and water power plants to give maximum all-round efficiency.

(2). The relative advantages of high voltage D.C. and A.C. generation and transmission for short distances.

(3) The operation of automatic and semi-automatic generating stations.

Tidal Power.—The question of tidal power has received much attention during the last few years. In this country it has been considered by the Water Power Resources Committee of the Board of Trade, who have issued a special tidal power report dealing more particularly with a suggested scheme on the Severn. The outline of a specific scheme on the same estuary was published by the Ministry of Transport towards the end of 1920.

In France a special commission has been appointed by the Ministry of Public Works to consider the development of tidal power, and it has been decided to erect a 3,000 k.w. experimetnal plant on the coast of Brittany. With the view of encouraging research, the Government proposes to grant concessions, where required, for the laying down of additional installations.

The tidal rise and fall around our coasts represents an enormous amount of energy, as may be exemplified by the fact that the power obtainable from the suggested Severn installation alone, for a period of eight hours daily throughout the year, would be of the order of 450,000 horse-power.

Many suggestions for utilising the tides by the use of current motors, float-operated air compressors, and the like, have been made, but the only practicable means of utilising tidal energy on any large scale would appear to involve the provision of one or more dams, impounding the water in tidal basins, and the use of the impounded water to drive turbines.

The energy thus rendered available is, however, intermittent; the average working head is low, and varies daily within very wide limits, while the maximum daily output varies widely as between spring and neap tides.

If some electro-chemical or electro-physical process were available, capable of utilising an intermittent energy supply subject to variations of this kind, the value of tidal power would be greatly increased. At the moment, however, no such process is commercially available, and in order to utilise any isolated tidal scheme for normal industrial application it is necessary to provide means for converting the variable output into a continuous supply constant throughout the normal working period.

Various schemes have been suggested for obtaining a continuous output by the co-ordinated operation of two or more tidal basins separated from each other and from the sea by dams with appropriate sluice gates. This method, however, can only get over the difficulty of equalising the outputs of spring and neap tides if it can be arranged that the maximum rate of output is that governed by the working head at the lowest neap tide, in which case only a small fraction of the available energy is utilised.

When a single tidal basin is used it is necessary to provide some storage system to absorb a portion of the energy during the daily and fortnightly periods of maximum output, and for this purpose the most promising method at the moment appears to involve the use of an auxiliary high level reservoir into which water is pumped when excess energy is available, to be used to drive secondary turbines as required. It is, however, possible that better methods may be devised. Storage by the use of electrically heated boilers has been suggested, and the whole field of storage is one which would probably well repay investigation.

If a sufficiently extensive electrical network were available, linking up a number of large steam and inland water-power stations, a tidal power scheme might readily be connected into such a network without any storage being necessary, and this would appear to be a possibility which should not be overlooked in the case of our own country.

Investigation necessary.—A tidal power project on any large scale involves a number of special problems for the satisfactory solution of which our present data is inadequate.

Thus the effect of a barrage on the silting of a large estuary, and the exact effect on the level in the estuary and in the tidal basin at any given time can only be determined by experiment, either on a small installation, or preferably on a model of the large scheme.

Many of the hydraulic, mechanical, and electrical problems involved are comparatively new, and there is little practical experience to serve as a basis of their solution.

Among these may be mentioned :—

(1) The most advantageous cycle of operations as regards working periods, mean head, and variations of head.
(2) The methods of control and of sluice gate operation.
(3) Effect of changes of level due to wind or waves.
(4) The best form of turbine and setting and the most economical turbine capacity.
(5) The possibilities of undue corrosion of turbine parts in salt water.
(6) The best method of operation; constant or variable speed.
(7) Whether the generators shall be geared or direct driven.
(8) Whether generation shall be by direct or alternating current.

The questions of interference with navigation and with fisheries; of utilising the dam for rail or road transport across the estuary; and, above all, economic questions connected with the cost of production, and the disposal of the output of such an installation, also require the most careful consideration before a scheme of any magnitude can be embarked upon with assurance of success.

In view of the magnitude of the interests involved, and of the fact that rough preliminary estimates indicate that to-day current even for an ordinary industrial load could be supplied from such an installation at a price lower than from a steam generating station giving the same output with coal at its present price, it would appear desirable that these problems should receive adequate investigation at an early date.

Facilities for Research in Hydraulic and Cognate Problems.—In view of the considerations already outlined, and especially in view of the large part which British engineering will probably play in future water power developments, the provision on an adequate scale at some institution in this country of facilities for research on hydraulic and cognate problems connected with the development of water power is worthy of serious attention.

At present the subject is treated in the curricu[illegible] the engineering schools of one or two of [illegible]ersities, but in no case is the laboratory [illegible]ally adequate for the purpose in

What is required is a research laboratory with facilities for experiments on the flow of water on a fairly large scale; for carrying out turbine tests on models of sufficient capacity to serve as a basis for design; and, if possible, working in conjunction with one or more of the hydro-electric stations already in existence, or to be installed in the country, at which certain large scale work might be carried out.

The provision of such a laboratory is at the moment under consideration in the United States, and in view of the rapidity with which the designs of hydraulic prime movers and their accessories are being improved at the moment, it would appear most desirable that the British designer, in order that the deservedly high status of his products should be maintained and enhanced, should at least have access to equal facilities, and should, if necessary, be able to submit any outstanding problems to investigation by a specially trained staff.

The extent to which our various engine laboratories have been able of recent years to assist in the development of the internal combustion engine, and to which our experimental tanks have assisted in the development of the shipbuilding industry, is well known to most of us, and the provision of similar facilities to assist in the development of our hydro-electric industry would probably have equally good results in this connection.

As a result of representations made by the Water Power Committee of the Board of Trade, I understand that it has now been decided to initiate a Chair of Hydro-Electric Engineering in some one university, and it is greatly to be hoped that funds may be available to enable the necessary laboratory to be designed and equipped on a scale commensurate with the importance of the work which it would be required to undertake.

THE STUDY OF AGRICULTURAL ECONOMICS.*

ADDRESS DELIVERED BEFORE SECTION M (AGRICULTURE)

By C. S. ORWIN, M.A., President of the Section.

FOR the third year in succession the University of Oxford has been honoured by the selection of one of its resident members for the office of President of the Agricultural Section of the British Association, and on the occasion of the Edinburgh Meeting it may be of interest to recall that historically, at all events, the study of Agriculture and Rural Economy at Oxford takes second place to no university with the single exception of Edinburgh. I am not a scientist in the commonly accepted sense of the word, and nothing but my deep conviction of the need for wider recognition of the importance of the study of economics in connection with agricultural research work could have overcome my reluctance to assume an office in which I have been preceded by such a long line of distinguished men.

It is now about 25 years since research and educational work in agriculture began to be developed seriously in this country. Since that date, a very great deal of effort has been expended in investigating the forces by which plant and

animal life are controlled, and to bring natural science to bear in every way upon the problems of food production. Work along these lines has been productive of most valuable results to the farmer; but at the same time the fact has been overlooked that, when all is said, farming is a business, and if it is to succeed as such, it must be carried on with a clear regard for the economic forces which control the industry. So, whilst desiring nothing but the fullest recognition of work in the fields of natural science applied to the investigation of farming problems, I must express without any qualification the view that the equal importance of the study of these economic forces has never been adequately recognised. Educational and research work in agriculture which takes no account of the dominant importance of economics must always be ill-balanced and incomplete, for farming business requires for its proper control a consideration of human relationships, of markets, of transport, and of many other matters which should come within the purview of the economist, as well as, or even more than, a consideration of questions regarding the control of plant and animal growth with which the scientist, in the limited sense of the name, is concerned. No one could wish to deny the need for the close and continual study of the soil and the means by which it can be made to produce more abundantly; no one could deny the need for research work in problems of animal and plant life. But the main concern of the farmer is to know not so much that which he can *grow* and how best to grow it as that which he can *sell* and how to sell it at a profit. Given the necessary capital and labour, conditions may be contrived under which any soil may be made to produce any crop; but the wisdom or otherwise of embarking upon any particular form of production can be determined only by a study of economic forces. In Bedfordshire, for example, considerable areas of very moderate land are met with given up to a most intensive form of agriculture; but land equally suitable for a similar form of farming may be met with in many other parts of the country which is not producing a tenth part of the value in food products nor employing a tenth part of the capital and labour, whilst at the same time the systems under which it is farmed are fully justified by the results. The reason of the difference, as doubtless everyone realises, is that the land in the former case is so situated that it has access, in the first place, to supplies of organic manures on an abundant scale and at a cheap price, and in the second place, to markets crying out for its produce, whilst one or both of these facilities are denied to the other areas. In the Chilterns district of Oxfordshire, farming a generation ago was mainly directed to the production of corn and meat, and nothing that has arisen out of the work of the investigators along lines of natural science would have called for any radical changes in agricultural policy on these soils. But economic forces, inexorable in their effect, have brought about a revolution, and arable land previously under corn and sheep is now laid down to grass or occupied with fodder crops for the maintenance of the dairy herds which have replaced sheep throughout the area. Again, in the hill districts of England and Wales there occur combes and valleys admirably adapted by soil and climate to the production of potatoes, and the highlands of Devonshire and Somerset may be cited in illustration. In these places, however, in the majority of cases, even though good markets may exist—Somerset, for example, imports potatoes—the lack of transport facilities makes it impossible for the farmers to produce anything which does not go to market on four legs. Coming last to the question of human relationships, we find that it is possible to organise much more intensive forms of agriculture than any of our own, which would be an enormous advantage to a consuming nation like Britain; examples of such are to be met with in varying degrees of intensity in many countries. The Chinese, one reads, have increased production per unit area to an almost incredible extent, and in a lesser degree a similar state of affairs exists in parts of France and in Belgium (so often held up to us in this country as a model of productive capacity which we should strive to emulate). But in all these places the results are only achieved by a prodigal use of labour. The nation gains, no doubt, in the volume of produce available for its consumption, but the individual producer, deprived under this system of the opportunity to apply his manual effort in conjunction with an adequate amount of capital and land, is sacrificed to the consumer's advantage, and is driven to spend himself, year in and year out, for a reward for his toil which the British worker, with so many alternative openings in more profitable directions available for him under our industrial system, would never for one moment submit to. From what I have read, I imagine that the fact which drove so many Scottish crofters across the seas was much less the selfishness of deer-stalking landlords than the opportunity for exchanging a few acres of rocks and heather in the Highlands for 160 acres of the virgin soil of Canada. People only submit to poor conditions of life when they have no alternative, and one of the most important studies awaiting the investigator of agricultural economics is that of the lines on which to develop the industry so as to give the worker the biggest reward for his toil.

These few illustrations may serve to indicate the over-riding importance of the economic factor in forming just as in any other business. It is a common experience in industry that many scientific and technical processes are possible which are not profitable, and it is in the light of the profit that they leave that all of them must be judged.

Economic conditions are subject to continual change, and the variations may be both sudden and extreme. This makes it the more needful to be continually recording experience and to examine it for the facts that emerge from which to obtain guidance for future policy. Much information is required both for national and individual guidance. Of late years, for example, there has been much advocacy of more intensive cultivation of the soil; it is said that by closer settlement and more intensive methods the production from the land could be much increased. On the other hand, there are those who advocate a development of extensive farming as being the only means by which to attract capital to the land and to pay the highest wage to the worker. Both sides to this controversy can and do produce evidence in support of their views, and some

TABLE I.—*Production per Unit of Land and per Unit of Labour from Holdings of Various Sizes.*

	Group	No. of Farms in each Group	Average size of Farms	Average Arable Land per cent.	Altitude	Average Rent per acre	Average Men per 100 acres	Sales per acre	Sales per man.
	Acres.				Feet	s. d.		£ s. d.	£ s. d.
I.	0-50	5	39	17	341-360	32 10	7·1	11 19 11	168 19 0
II.	50-100	10	78	22	319-384	33 0	6·4	9 19 2	156 2 0
III.	100-150	14	138	21	370-453	27 2	4·2	7 19 1	189 0 0
IV.	100-250	11	201	11·7	330-411	28 4	3·3	7 5 8	222 12 1
V.	over 250	12	356	18·0	286-435	26 5	2·6	8 4 4	316 19 0

TABLE II.—*Producer's, Wholesaler's, and Retailer's Prices for Market-Garden Produce, January*, 1921.

Article	Cabbages, medium grade, per dozen s. d.	Cabbages, bottom grade, per dozen s. d.	Cauliflowers, top grade, per dozen s. d.	Sprouts, top grade, per 28lbs. s. d.	Turnips, medium gde. per cwt. s. d.
Producer	0 3	0 2½	3 0	3 6	3 0
Wholesaler	1 0	0 9	5 0	—	5 6
Retailers—					
(*a*) Stalls and Barrows	2 6	2 0	6 0	—	14 0
(*b*) Suburban shops	3 0	2 6	8 0	—	14 0
(*c*) Stores and high-class shops	4 0	3 0	10 0	14 0	18 8

figures derived from a survey made by my colleague, Mr. J. Pryse Howell, will serve to illustrate both. The total area surveyed was 9,390 acres, divided into 52 farms of various sizes, and the region was selected by reason of the uniformity of the general conditions. All available data for each holding were collected, and after grouping the farms according to acreage, the figures were thrown together and averaged for each group, with results as shown in Table I.

It will be noted that the conditions under which the farming is carried on in the various groups show no material differences as between one group and another, except in the matter of area. There is a tendency for rent to fall as the size of the holdings increases, but it is not pronounced, and in one case (Group IV.) the percentage of grassland to arable land is considerably higher than in the rest; but, considering the variations which must be expected in the conditions prevailing over any area of 15 square miles in extent, it may be claimed that in respect of altitude, quality of land, and proportion of arable to grass the holdings in these five groups are fairly comparable. Taking the results as they stand, the fact emerges that employment and production vary inversely with the size of the holding, but that the production per man employed varies directly with the size of the holding. Thus, on the one hand, the advocates of closer settlement and the intensive methods which must necessarily follow if men are to live by the cultivation of small areas of land would seem to be justified in that the results shown by the survey indicate the highest amount of employment and the greatest product-value in the smaller groups. On the other hand, the advocates of more extensive methods of farming can point to their justification in that it is clear that the efficiency of management is greatest in the larger groups if the standard of measurement be that of product-value per man employed. However, it is clear that either party is drawing conclusions from incomplete data. The efficiency of any farming system can only be judged by an examination of the extent to which all the factors of production are utilised and balanced under it. Each of the assumptions made from the figures above ignores entirely the factor of capital. Land, labour, and capital are all required for production, and the *optimum* system of farm management is that which utilises all three together so as to secure the maximum result from each. If information were available as to the capital utilised in each of the five groups in the survey it might be found that in the smaller groups labour was being wastefully employed, and that an equal number of men working on a larger area of land with more capital, in the form of machinery equipment, would produce an equal product-value per unit of land with a higher rate of output per man employed. Equally it might be found that in the larger groups the use of more labour, or a reduction in the area of land, might produce the same product-value per man with a higher rate of output per unit of land. Obviously there can be no absolute answer to the question of what constitutes the most economical unit of land for farm production. The quality of land in certain cases, and market, transport, and climatic conditions in many more, make it impossible to determine even within wide limits the size of the holding on which the principal factors of production can be employed with maximum effect. Within similar areas, however, and in limited districts, much work can and should be done by agricultural economists to collect evidence on this point for the information of all concerned with the administration of land.

Another matter of the utmost importance to the farmer and to the public alike, and one which is crying out for investigation on a large scale, is the distribution and marketing of farm produce. Attention has been drawn at many times to the discrepancy between the price realised by the producer and the price paid by the consumer for the same article. In connection with market-garden produce, for example, the Departmental Committee on the Settlement or Employment on the Land of Discharged Sailors and Soldiers stated in their Report (Cd. 8182, 1916) that "the disparity between the retail prices paid for market-garden produce in the big towns and the small portion

of those prices received by the growers is utterly indefensible. It demonstrates a degree of economic waste which would ruin any other industry." No evidence was published by the Committee as to the facts upon which this conclusion was based, but a recent inquiry made by the Ministry of Agriculture into the prices prevailing at various stages in the distribution of vegetables in London may be quoted in confirmation of it. Figures were collected to show the amount received by the producer, the wholesaler, and the retailers for various classes of everyday garden stuff, with results as shown in Table II.

One has only to glance at the prevailing methods of distribution to realise their wastefulness. The street in which I live contains ten houses, and each day four milk-carts, three bakers' carts, three grocers' carts, and two butchers' carts deliver food to them. Twelve men, horses, and carts, not to mention a host of errand-boys on foot and on cycles, to deliver food to ten families! While we are content with such a loose organisation of distribution as this represents, we must not wonder if prices received by producers seem disproportionate to those paid by consumers, particularly when the produce partakes of the nature of market-garden stuff, bulky, perishable, and of low value. But apart from the question of methods of distribution, and the advantages to producer and consumer alike which would accrue from some co-operative organisation directed towards the elimination of unnecessary retailers who do no real service to either of them, an investigation of transport and marketing costs would show to what extent they are being exploited by the distributor. The farmer suffers equally with the market-gardener. At the present time I am getting 1s. 9d. per gallon for milk sold to a middleman from my farm, and for this milk my wife is charged 3s. per gallon I am selling lamb at 1s. 4d. per pound for which she is charged 2s. 6d. per lb., and if the drought had not upset the crop I should be selling potatoes at an equal disparity as between wholesale and retail prices. Can anyone say whether these figures do or do not represent a fair division of total cost as between producer, retailer, and consumer? It may be asserted with confidence that no one can speak with authority upon the subject. The only figures which we have been able to collect at Oxford on the cost of distribution relate to milk, and the most recent that we have are those for the year 1918. In that year in a Midland manufacturing town we found that the distribution costs of a large producer-retailer were as follows:—

	£	s.	d.
Labour: Manual and clerical ...	1,242	10	2½
Horse	497	0	9½
Rent	75	0	0
Sundry purchases, depreciation, general expenses, &c.	430	2	1
Total cost	£2,244	13	1

Number of gallons of milk distributed 112,833
Cost of distribution per gallon ... 4·77d.

Doubtless the conditions have changed since that year, nor is it possible to generalise from a single example; but, nevertheless, the figure for the gallon-cost seems to indicate that both farmer and consumer are suffering in the interests of the distributor, though it is impossible to say without further investigation whether the profit secured by retailers generally is excessive, or whether the difference between distribution cost and the margin out of which it is paid is necessary owing to an excessive number of distributors.

As to the other points named, meat and potatoes, no evidence exists at all, and the position with regard to them and also to milk is only indicated to emphasise the need for a full investigation of the economics of distribution.

At the present time labour problems afford a useful example of the need for further investigation of the economic problems of agriculture. The agricultural industry has been fortunate in that it has escaped the serious labour troubles which have shaken many other industries so badly during the past few years. This has been due in part, no doubt, to the closer personal relations which exist between employer and employed in agriculture than in other enterprises, and in part to the intervention of that often unfairly criticised body, the Agricultural Wages Board, but agricultural employers have also to thank the fact that agricultural labour is difficult to organise. Much controversy in the past would have been avoided, and the possibility of future difficulties could be faced with more confidence, if all the facts relating to labour had been and were being studied over the country generally. The labourer is often blamed for results which are due to the inefficiency of the farmer as a manager. When wages were low it may have been that the labourer was the cheapest machine, but in proportion as his remuneration approaches more nearly to the standard of reward in competing industries, so will the necessity for making his work more productive be intensified. The value of the output from the farm per man employed is not the only measure by which to gauge the efficiency of the management, but is certainly one of primary importance. A man with a spade can dig an acre of land in about two weeks at a cost to-day of about £4 10s.; a horseman and a pair of horses can plough an acre in about a day-and-a-half at a cost of £1 15s.; a farm mechanic on a tractor can break up an acre in about a quarter of a day, and although in the absence of sufficient data the comparison cannot yet be completed by reference to the cost of motor ploughing, it is fairly safe to suggest that when all the factors are considered—speed, less dependence upon atmospheric and soil conditions, as well as actual cost—there will be a still further advantage to be derived by investing the manual worker with the control of mechanical power. Thus it may be that high labour costs to-day are due in many cases less to the inefficiency of labour and more to the inefficiency of management. In a recent issue of *The Times* an agricultural writer expressed the view that if the means existed for determining the proportion of the net returns of agriculture accruing to-day to labour, it would be found that labour was taking an excessive toll of farming results. This view is probably very generally held, and it affords a good example of the misconceptions which may and do arise in people's minds in the absence of exact information upon which to base their assertions. This happens to be one of the questions which have been the sub

ject of investigation at Oxford, though only on the small scale that the means at the disposal of the University has admitted. An investigation was made before the War of the Distribution of the Net Returns of Agriculture as between landlord, farmer, and labour. The net returns are calculated from the net output, and the net output was ascertained by the method followed in the Final Report on the First Census of Production of the United Kingdom, 1907 (Cd. 6320). Under this method the cost of materials at the works is deducted from the value of the output at the works, and the difference constitutes for any industry the fund from which wages, salaries, rent, royalties, rates, taxes, depreciation, advertisement, and sales expenses, and all other similar charges have to be defrayed, as well as profits. The same basis of calculation was adopted in the Report of the Board of Agriculture and Fisheries on the Agricultural Output of Great Britain (Cd. 6277) made in connection with the Census of Production Act, 1906. In applying this measure of net output to the agricultural industry, the method is to value the farmer's capital at the beginning of the year and to add to this figure all live and dead stock bought during the year, foods, manures, tradesmen's bills, on-cost and establishment charges, &c., and to deduct the total from the sales during the year added to the valuation of the farmer's capital at the end of the year. Only in the case of the workers is their share of this net output available as net income. The landlord has to incur a considerable expenditure upon the farm in the way of repairs and maintenance, and this must come out of his share of the net output. From an enquiry conducted by the Land Agents' Society in the year 1909, it appeared that about 30 per cent. of the rent received by the landlord is expended by him in repairs, insurance, management, and similar payments necessary to maintain the property in a condition to produce the rent. The farmer, too, may have certain expenses to meet not covered by those deducted in arriving at the net output, and his share of this figure has also to cover some rate of interest on his working capital, besides the reward due to him for the exercise of his managerial functions. Thus, in considering the distribution of the profits of agriculture between the three interests concerned, it is necessary to distinguish between net output as defined in the Census of Production and what may be termed the net returns. The net returns are ascertained by deducting from the net ouput any additional expenses of the business *not already allowed for*; a sum representing about 7 per cent interest on the farmer's capital (this figure being based in current rates for money), and one-third of the amount of the rent.

This method for calculating net returns was applied in 1913 to six farms scattered all over the country, and differing from each other in almost every way as to systems of management, soil, locality, and so forth, and it was found that the proportions accruing to each of the three interests varied hardly at all, and that it would be safe to say that 20 per cent of the total was going to the landlord, 40 per cent to the farmer, and 40 per cent to labour. Owing to the disorganisation of the work arising out of the war, it was not possible to carry on the investigation on each of these six farms, but it was continued in connection with one of them down to the year 1920. This farm may fairly be described as typical of "average to rather indifferent" conditions. It was a tenant-farm, about 1000 acres in extent, commanding a rent of less than £1 per acre, about three-quarters arable, situated on light to medium land, seven miles from a station, and farmed mainly for production of corn and meat. Taking the above proportions, namely, 40 per cent each to farmer and labour and 20 per cent to landlord as the pre-war rate of distribution, and calling each of these shares 100, the proportion of distribution between the three interests varied during the following six years as shown in Table III.

TABLE III.—*Distribution of the Net Returns from Farming between Landlord, Farmer, and Labour during the years* 1913-14—1919-20.

Year	Landlord	Farmer	Labour
1913-14 (Standard)	100	100	100
1914-15	97	104	99
1915-16	94	108	98
1916-17	91	115	94
1917-18	90	111	99
1918-19	87	115	98
1919-20	89	109	102

The figures are interesting in several ways. In the first place they seem to disprove the suggestion referred to above, that labour has been taking an undue share of the net returns from farming, for an examination of the figures in the "Labour" column shows that until the institution of the Agricultural Wages Board in 1917, the tendency was in the direction of a slight but steady reduction in the proportion coming to the workers; the effect of the Wages Board Orders was to steady this tendency and, ultimately, to bring labour back approximately to the position it occupied in 1913-14. If the figures could have been continued for another year, it is likely that they would show a material increase in the workers' share, but, even so, it would be found that this increase had been achieved without reducing the farmer's share below his pre-war proportion. In the second place, the figures confirm the experience of landowners in that the landlord has received no part of the increased prosperity of farming, whilst, as everyone knows, his expenses of maintenance have enormously increased. Briefly, the situation is that, thanks to the Agricultural Wages Board (and its appointed members may take heart from the fact), the workers have been maintained in the same position as regards their share in the net returns as that in which they were before the war, whilst the farmer has received his share in the increase realised during the past few years, together with that which would have gone to the landlord had the pre-war scale of distribution been maintained. Rents and wages under normal conditions are slow to adjust themselves to changes in farming fortune, and, except in a time of violent economic upheaval, it is right that this should be so, for if the landlord may be regarded as a debenture holder, and labour as a preference shareholder, then the farmer, as the ordinary or deferred shareholder, has to bear the brunt, and if he must take the kicks, so also is he entitled to the half-pence.

Turning now from problems in which either the nation generally or whole classes of the industry are concerned, it may be stated that there are

many economic problems arising on the farm itself in the solution of which the individual farmer should be able to derive help from the economist. Some of these problems are so simple that their solution should be obvious, but the fact remains that waste in its most easily eliminated forms is constantly to be met with on the farm. The need *for the study of the economic use of manual* labour has already been referred to in another connection, but, granted that the balance between the employment of land, capital, and labour on any farm has been established, cases are continually met with where labour is being mismanaged. It is a not uncommon practice at threshing-time to take the horsemen from their work to assist at threshing, and as this operation can only be performed in dry weather, it may be assumed that the horses might usually be employed on threshing days. With manual labour costing about 7s. 6d. a day, and horses about 5s. a day, the advantage of hiring casual labour for threshing, even at high rates of pay, will be obvious when it is remembered that the horseman whose horses are standing idle represents a daily cost for the manual work performed by him of some 18s. On a Midland Counties farm, where *the maximum possible horse-hours in a certain* week in November last were 238, the time actually worked by horses was found to be 87, owing to threshing operations, and the wastefulness of the labour-management in such a case is obvious Again, employers in certain cases object to paying Saturday overtime to men willing to work, because overtime payments are at a higher rate than those for ordinary time, but they overlook entirely the fact that the Agricultural Wages Board provides no overtime payments to the horses, and and thus the heapest horse-labour on the farm is that performed on Saturday afternoon at overtime rates of pay to the horsemen.

Everyone realises, of course, the importance of *keeping horses busy*, but *not everyone* thinks how heavily the cost of manual labour is increased by idle horses. The maximum number of working days in a year is 312, a total obviously impossible of attainment in practice. Such records as are available show that the days actually worked by horses on the farm will not usually exceed four-fifths of the maximum. More time may be lost in summer than in winter, a fact not generally realised, and the period of maximum unemployment falls between haymaking and harvest. The busy seasons are, of course, the autumn and the spring, when the preparation of the ground for winter and spring corn is going actively forward. In the year 1918, figures were collected to show the percentage of days worked compared with "possible days" in each month on four farms distributed pretty evenly over England, and the results, thrown together, are as follows:—

TABLE IV.—*Percentage of Days Worked to Possible Horse-Days on Four Farms in* 1918.

	Per cent		Per cent
January	67	July	38
February...	82	August	65
March	77	September ...	78
April	74	October ...	80
May	70	November ...	67
June	56	December ...	64

Although the figures represent an average of four farms, it is noteworthy that the results on the individual holdings varied one from another in degree only, and that the months of maximum and minimum employment were the same in every case. The loss of time is far more serious than many people realise. The maximum possible horse-days in the year are 312, and the cost per day of the horses on the above four farms on this basis was 2s. 7d., whereas, owing to the time lost, the cost on the basis of days worked was 3s. 7d. Whilst some difference is inevitable, so great a discrepancy as these figures reveal can be avoided by skilful management, and one of the tests of the farmer's efficiency is provided by an examination of the distribution of horse-labour throughout the year on his farm. His cropping and other work should be so contrived as to provide for the uniform utilisation of horse-labour month by month. Under skilful management the differences in the number of days worked by horses from year to year are extraordinarily slight. On an East Midlands farm, employing 23 horses, the days worked per horse during the past six years have been as follows. Days worked per horse: 1913-14, 250·25; 1914-15, 247; 1915-16, 243; 1916-17, 236; 1917-18, 243; 1918-19, 244·5.

It may be noted, in passing, that figures such as *those given for the seasonal employment of horse-*labour emphasise the need for a study of the place of the agricultural tractor in farm management, for the busiest times of the year synchronise, more or less, with the seasons when the weather is more uncertain and suggest that the application of speedier mechanical power to field operations, in substitution for slower horse-power, would result in economic advantages in certain cases

In connection with the study of economics on the farm, the question of agricultural costings naturally suggests itself. Farmers, as a class, are not accountants and much less are they cost accountants, but this has not deterred many of them from taking part in discussions of farming *costs which have been going on in the Press and* in the Food Controller's offices for some time past, and the confusion of thought on the question of what cost of production really is which these *discussions have revealed is evidence of the need* for study and education in costing processes. Few things can be of greater service to the farmer than scientific book-keeping carried out and interpreted with proper understanding, but few things can deceive him more than costing wrongly conducted or misinterpreted. The need for accurate thinking is evidenced in nothing, perhaps, so much as in conneciton with the question of the valuation of the raw materials grown on the farm, the hay, straw, roots, pasturage, &c., produced for home consumption in the process of manufacturing milk and meat. There can be only one basis of value possible, namely, their cost to the farmer, but it is contended, almost universally, that their *market price should be substituted for the sums* that he has actually paid for them. As a matter of fact, the bulky feeding stuffs usually produced and consumed at home rarely have any market value at all. A market value is one that can be realised in the market. Thus, corn, meat, and certain other commodities have clearly market value because they are always saleable, but if all the farmers in the country decided to sell their mangolds they would find that the market for mangolds is non-existent, and that the prices

quoted in market reports represent a few deals to satisfy an infinitesimal demand. The same is true of straw, and, in a slightly less degree, of hay in normal times. Even if the difficulty of fixing the market prices of certain products, such as turnips, straw, or hay, be ignored, and if it be assumed that there be a free market in such things, a fuller consideration of what the farmer really does in feeding them to his stock will show how inapplicable such values are to his case. The market value of an article is the figure at which a willing buyer and a willing seller can agree to do business. The farmer who contends that he is justified in "selling" his roots or hay to his stock is selling them, in point of fact, to himself, and seeing that there is only one party to the transaction there can be no market and, consequently, no market price. In the majority of cases each of these things is grown because the farmer has need of them in the production of the article or articles of food towards which his management is directed. If he could buy them more cheaply than he can grow them he would surely do so, but to regard himself as a merchant instead of a manufacturer, and then to trade with one department of his farm against another is to involve himself in paper transactions which have no foundation in fact, and which may lead to disastrous conclusions. To take, for example, the cost of milk production. It is usual to argue that hay consumed by the cow should be charged at its market price. It may well be that in consequence of a temporary or of a local demand it will pay a farmer better to sell hay rather than to produce milk, and one of the main functions of book-keeping is to enable him to make a decision on such points as this. But he cannot expect to have it both ways; if he sells hay he cannot produce milk, and *vice versa*. Many farmers contract at summer prices for their winter supply of feeding stuffs, but a man who has bought linseed cake at a pound per ton less than the price current at the time when he is consuming it would hardly think of charging it to bullocks at any other price than that which he actually paid, and it is this figure, the actual cost to him, which must be the measure of the value of all raw materials, whether they be bought in the market, or whether, for the sake of convenience and economy, they be grown on the farm.

Lastly, I want to urge, and particularly before a gathering such as this, the importance of agricultural economics in agricultural education. The fact is realised, no doubt, by many teachers, but until a sufficient body of data bearing on the study of farm management can be made available to them, it is impossible for them to give to the teaching of practical agriculture that solid economic basis which is fundamental, and the teacher is driven to include in his instruction much to which the economic test has never been applied and to exclude more for which no basis for teaching exists at all. Given the requisite body of information, it would not only be possible but necessary to recast the whole foundations upon which the teaching of practical agriculture rests.

I am not one of the few who appear to derive satisfaction from making comparisons unfavourable to British agriculture with that of other countries, but, when we look at the work which is being done in the United States, in Italy, Germany, Switzerland, and even in Russia, before the war, it is surprising to reflect that the agriculturists of the nation which produced Adam Smith, Ricardo, and John Stuart Mill should have been so slow to realise the need for a fuller organisation for the study of agricultural economics.

THE CHEMISTRY OF COLLOIDS.

By HUMPHREY D. MURRAY,
Exhibitioner of Christ Church, Oxford.

THIS branch of science dates from an experiment of Thos. Graham in the year 1862 upon the rates of diffusion of various substances through animal membranes. When he came to examine his results, Graham found that he could divide all the substances he had examined into two classes, according to their rates of diffusion. He gave the name of crystalloids to those substances with a high rate of diffusion, and colloids to those with a low rate, thereby drawing a sharp distinction between the two groups. As time went on, however, many substances were found, which, according to their treatment, appeared either as crystalloids or colloids; and as their number increased, Graham's sharp line of demarcation was relinquished, the names colloid and crystalloid being retained to denote general states of matter, rather than definite classes of substances.

Besides the difference in their rates of diffusion, solutions of colloids are distinguished from those of crystalloids by other properties which they exhibit to a greater or lesser degree, and which, when taken together, serve to distinguish the two types of solution. These properties are:—

(1) Appearance of Brownian movement under the ultramicroscope.
(2) Exhibition of the Tyndall effect;
(3) A small osmotic pressure;
(4) The phenomena of cataphoresis and endosmosis;
(5) The phenomena connected with electrolytic coagulation.

All these properties lead to the conclusion that the so-called colloidal solution is not a solution in the true sense of the word, since it must contain more than one phase. It seems very probable that the "dissolved" substance is present, not in the form of simple molecules, but as comparatively large aggregates of molecules, which are still small in comparison with ordinary dimensions. A colloidal solution, therefore, is not truly homogeneous, although such a condition is somewhat difficult to define, and it stands half-way between a true solution on the one hand and a coarse suspension on the other.

If a colloidal solution is viewed by directly transmitted light it usually appears perfectly clear. If, however, a beam of intense light be projected at right angles to the line of vision, the solution appears milky, the phenomenon being known as the Tyndall effect. When a similar arrangement is viewed through a microscope, it is found that the light is diffracted by the colloidal particles, and they appear as constantly moving points of light. This constant motion was first observed by the botanist Brown in the case of pollen grains suspended in water, and for some time its explanation was uncertain. It is now

apparent, however, that the motion is due to the continual irregular bombardment of the scarcely visible particles by the completely invisible molecules of the liquid in which the particles are suspended. Observation of this movement through the microscope, notably by Perrin, has resulted in considerably increasing our knowledge of the molecular properties of liquids.

The methods of producing colloidal solutions are very numerous, and may be said to vary with each substance. Four general methods are, however, recognised :—

(1) *Physical.*—This includes the addition of a definite peptising agent, that is some active body, which (probably by adsorption) breaks down the substance from the massive state into a colloidal solution. Such action is seen in the effect of alkalis in peptising various metal oxides. Peptisation may also be brought about by washing out the coagulating agent from a precipitate, but it will only be successful if it is possible to remove completely the precipitating agent, and if coagulation has not gone too far. Under this head also is included the preparation of colloidal solutions by the gradual replacement of a solvent by an inert liquid : for instance, by slowly pouring a solution of mastic in alcohol into water.

(2) *Chemical.*—An example is the formation of colloidal solutions of metallic gold by reduction of solutions of gold chloride with tannin or formaldehyde. Von Weimarn considers it possible, by suitably adapting the conditions, to produce any precipitate in states of aggregation ranging from a definitely colloidal form to a coarse crystalline mass, and he has shown this to be true in the case of barium sulphate.

(3) *Mechanical.*—When a solid is ground extremely fine and the product treated with water, part of it will form a colloidal solution which will be more stable if a suitable peptising agent is present. This has been done in the case of several metals.

(4) *Electrical.*—If an arc be struck between two metallic electrodes under water, portions of the metal are disintegrated, and a colloidal solution results. Bredig and Svedberg, using water and other liquids, have produced colloidal solutions of Fe, Cu, Hg, Al, and other metals.

All the methods enumerated above aim at producing a particle which is small enough to be kept in motion by the Brownian movement. If such a particle be produced, it will stay suspended in the medium in which it was formed, and not precipitate under the influence of gravity. For complete stability, however, it is necessary that two particles shall not coalesce when they come in contact, which would follow from the surface tension of the particles; and to bring this about it is necessary that the particles shall be furnished with some protective envelope. This may be effected by the adsorption of another substance upon the surface of the particle; a second way, of which it is easier to treat, is that the particles shall carry an electric charge, and thus repel one another. If, then, the particles in a colloidal solution are made sufficiently small and are prevented from coalescing, the solution will be stable. What this size may be is a question of experiment, but we can say roughly that suspensions, emulsions, and colloids have particles whose radii are of the order 10^{-4}, 10^{-5}, 10^{-6} cm. respectively. This result is arrived at by using the ultra-microscope, and by filtering through collodion filters of definite composition, which retain all particles above a limiting size.

It was at one time thought that the charge upon the particles was due to frictional contact between the particles and the medium in which they were dispersed. Such an idea has now been discarded, but it has not been replaced by anything very definite. The general opinion as to the cause of the charge is divided under three heads; that the charge is due to the ionisation of some foreign substance present in the colloid at the moment of formation; that the charge is due to the actual ionisation of the colloid itself; or that the charge is due to the preferential adsorption at the surface of the colloid of ions present in the dispersion medium. No reliable method has as yet been found for measuring the absolute charge upon the particles, but rough measurements have been made, which are not even very concordant, from the movement of particles when placed between two charged electrodes (cataphoresis). It is obvious that under such conditions, positively charged particles will move to the cathode and negatively charged particles to the anode. It is thus found that metallic hydroxides, *e.g.*, $Fe(OH)_3$, methyl violet, and other dyes are positively charged in water; while colloidal metals, sulphur, sulphides, silicic and stannic acids, eosin, indigo, resin, &c., are negatively charged. An observation of Hardy's in this connection is interesting; he found that in acid solution albumin is positively charged, being negatively charged in alkaline solution, and neutral in pure water. This would seem to support the theory that the charge is due to the adsorption of the hydrogen or hydroxyl ion. By measuring the actual velocity of the particles under a known potential difference, and making certain assumptions, it is possible to calculate the potential difference between the colloid and the medium, and hence the charge upon a particle. In this way Lewis, from some data by Burton, deduced a rough value of 8×10^{-5} E.S U. for a platinum particle.

The stability of the particle is due, as has been said, to a mechanical or electrical layer. If in the latter case, the charge upon the particle is removed, or reduced, we should expect coagulation to occur; and it appears very probable that such indeed is the case. On the addition of electrolytes to many colloidal solutions, precipitation takes place when the concentration of the electrolyte reaches a specific value. It seems quite possible that what takes place is a continued adsorption of oppositely charged ions (or something of that nature) until the effective protection due to the charge upon the colloid is removed, and coagulation occurs. It is found that the most actively precipitating ions are those carrying an opposite charge, whilst the higher the valency of the ion the greater is its precipitating power. This generalisation is known as the Hardy-Schulze Law. Whetham deduced on the basis of the theory of probabilities that the precipitating power of a series of ions of the same sign is proportional to a constant raised to a power representing the valency of the ion. Both these so-called laws are very rough generalisations, and are often found to break down. They represent

probably a single law of somewhat more complex nature defining the adsorption by a particle, of oppositely charged ions.

The chemistry of colloids is as yet still in its infancy, but it has wide-reaching applications—in trades such as tanning, dyeing, and brewing; in agriculture and sewage disposal; and in physiology and pathology. Its knowledge is very largely empirical, and further advance calls for unremitting research.

THE FOURTH DIMENSION AND RELATIVITY.

By F. H. LORING.

If any pre-eminent scientist had been asked, not many years ago, to write a chapter in science which could be regarded as *complete and*, so far as it dealt fundamentally with certain phenomena, *beyond criticism*, he might have chosen Newton's Laws of Motion for the title of his essay. To-day Newton's laws hold good in their practical application for a large group of phenomena, but the *principle of relativity has opened up a new and* extensive field of knowledge in connection with these laws, so that Newton's equations are being superseded by a more complete set of equations—due mainly to Einstein and to some extent to Minkowski and to H. A. Lorentz—which satisfy all the requirements of Newton and solve additional problems which were not known to Newton—and this is accomplished without a change in the fundamental structure of these new equations.

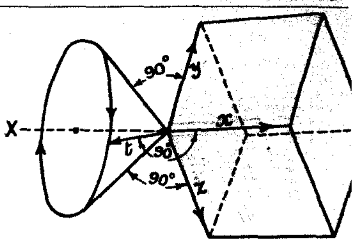
The mechanics thus created is very comprehensive, since it is applicable to light and to electricity, *i.e.*, to electro-magnetic-wave phenomena and to certain corpuscular radiations or motions, in particular to high-speed electrons. In general the presentment of phenomena is altered too.

No eminent scientist of to-day would regard Newton's laws as examples of crude and imperfect formulisations of fact. He would have the profoundest respect for Newton's great work, but he would have to admit that even the most complete, and at the same time the greatest mental achievement of man is not final for all time. The study of new phenomena in detail may any day add a new chapter to the most finished work even though it had been perfected to the highest degree by the contributions from leading experimentalists.

The advent of the new relativity doctrine has brought into prominence the idea of a *fourth dimension*, and it may not be out of place to discuss briefly the theory from this point of view. Those who take pleasure in studying such recondite problems as the *fourth dimension* may be interested in the following geometrical device used merely as an introductory illustration.

Construct a proper cone and a cube as shown and so place the former that it will give right angles between its surface and any one of the edges x, y, z, of the latter, as illustrated by the accompanying figure. The axis X of the cone will, if extended, pass through the diagonally opposite corner of the cube.

Now a line t drawn on this cone will be at right angles to all the other lettered lines if it be imagined to revolve on the X axis at *infinite*



Note:—Angle of cone=70°56; or 180°−70°56 when the cone is formed round the three edges of a complementary cube. This affords an interesting paradox, for how can an acute and an obtuse cone give the 90° angles specified? The reader may find pleasure in solving this problem that is not at first sight obvious.

speed, so as to lie in all places at once. Such a line, therefore, answers to the fourth dimension; but it becomes, in consequence of its rotation, a volume figure in effect and involves *time* in its realisation, even though infinite considerations come into the matter.

Devices of this kind may be helpful in a sense, but they must not be pressed too far; it is better to study the equations which contain the *fourth* dimension by implication.

Minkowski's conception of *time* and *space* is of interest here, for he says: "Henceforth space in itself and time in itself sink into mere shadows and only a kind of union of the two can be maintained as self-existent." His relativity equations give support to this view. Extension in the abstract would involve a dimension such as length in the abstract, but extension in the concrete, as when a body moves from place A to place B, involves time and space, time being consumed in the operation. Thus a time-extension becomes involved; and this affords perhaps a definition of reality which agrees with Minkowski's labelling as will be seen presently, or, as H. G. Wells has practically said—a thing has no real existence without being projected in time. An *instantaneous being* is a mere abstraction devoid of any semblance of reality; but given successive instants of time it becomes a *living thing*. The terms "living" and "being" here refer to all matter. These are philosophical ideas but they have their counterpart or interpretation in the formulisation of physical phenomena along the lines laid down by Einstein, Minkowski, and H. A. Lorentz.

If now a point within the cube, as determined by three co-ordinates (x_1, x_2, x_3) be projected to a given time-place on the time-axis co-ordinate, or line considered as in rotation, a tube or cone would result which calls to mind Minkowski's *world-tube* idea, or *space-time filament*, as he also expressed it. The word "world" stands for physical phenomena: *i.e.*, point-time events, or real happenings. Minkowski's "world" can be described as a four-dimensional Euclidean space (continuum) which includes an imaginary time co-ordinate, and this has been given the mathematical symbolism $x_4 = \sqrt{-1} \cdot ct$ where c is the velocity of light, and this special mathematical device gives symmetry to the equations. In this mani-

fold system, if one specifies movement, a standard of movement must be adopted, just as one of length is adopted, and as Minkowski's time-space idea involves movement, the velocity of light becomes the datum-line unit, as it were, in the system. This constant enters into the *fourth* dimension because it is common to all three axes which are in movement. The following, taken from Einstein's article in *Nature* (Feb. 17, 1921) is of interest in this connection.

Euclidean Geometry of Three Dimensions.	*Special Theory of Relativity [Four Dimensions.]*
Corresponding to two neighbouring points in space there exists a numerical measure (distance ds*) which conforms to the equation $ds^2 = dx^2_1 + dx^2_2 + dx^2_3$	Corresponding to two neighbouring points in space - time (point events) there exists a numerical measure (distance ds) which conforms to the equation $ds^2 = dx^2_1 + dx^2_2 + ax^2_3 + dx^2_4$.
It is independent of the system of co-ordinates chosen, and can be measured with the unit measuring-rod	It is independent of the inertial system chosen, and can be measured with the unit measuring-rod and a standard clock. x_1, x_2, x_3 are here rectangular co-ordinates, whilst $x_4 = \sqrt{-1}\cdot ct$ is the time multiplied by the imaginary unit and by the velocity of light.
The permissible transformations are of such a character that the expression ds^2 is invariant, *i.e.*, the linear orthogonal transformations are permissible.	The permissible transformations are of such a character that the expression for ds^2 is invariant, *i.e.*, those *linear orthogonal* substitutions are permissible which maintain the semblance of reality of x_1, x_2, x_3, x_4. These substitutions are the Lorentz transformations.
With respect to these transformations, the laws of Euclidean geometry are invariant.	With respect to these transformations the laws of physics are invariant.

(Quotation ends here).

It should be noted that the term *invariant* means that there is no change in passing from one set of moving axes to another; or precisely, as a given alternating current phenomenon can be analyzed into working components, each one of which possesses the characteristic of *invariance* and observes a common law.

Relativity dynamics, or relativity equations involving a fourth-axis co-ordinate, regarded as representing time, enable problems hitherto unsolved to be solved when using the calculus and making each co-ordinate system a part and parcel as it were of each body in movement, so that in passing from one to the other the Lorentz transformation obtains.

Passing over considerable ground and turning to the culminating achievement of the theory in its more extended form (the *General* Theory of Relativity involving the Principle of Equivalence), the bending (or drawing-in—in the sense that converging railway lines would bring the trains closer together) of the course of light in passing close to the sun, owing to the concentration of the space-gravitational field (by analogy, the railway lines) round this massive body (due to the *mass-energy* of the sun as it might be termed), was clearly foreshadowed quantitatively by a development of the theory, and the phenomenon was verified by the photographs taken at the last total eclipse expeditions (see CHEMICAL NEWS, 1920, cxxi., 277).

*This is a distance between points exceedingly near together and it is called a *line-element*, which becomes a point event.—F.H.L.

NOTE ON FIELDING'S FORMULA CONNECTING CRITICAL TEMPERATURES AND PRESSURES.

By J. NEWTON FRIEND,
Municipal Technical School, Birmingham.

THERE is a certain fascination about numbers, and the application of mathematics to physical and chemical phenomena has revealed many laws and remarkable coincidences, which, in not a few cases, have proved of great value in elucidating intricate problems and in providing fresh avenues for research. Investigations of this type may be divided into two groups. To the former of these belongs that well-ordered and logical method of attack, which, based on certain assumptions, leads to the formation of laws, formulæ, &c., the correctness of which stands or falls, not by the method of calculation, but by the soundness or otherwise of the initial assumptions. A well-known illustration is Poiseuilles' famous formula for determining the viscosity of a liquid as derived by Laplace.

To the second class belong such coincidences and laws as are discovered by methods of trial, and not based upon any reasoned sequence. Kepler's laws of the planetary movements would appear to be an apt illustration. Both methods have yielded very valuable results. In a series of papers appearing in recent issues of the CHEMICAL NEWS, various formulæ have been suggested by Fielding, in which numerical relations between certain physical data have been discovered. The method has clearly been that of trial and failure, and it is interesting to enquire whether the relationships are purely coincidences, or if they can be substantiated on theoretical grounds.

The formula given by Fielding (CHEMICAL NEWS, 1918, cxvii, 379) connecting critical temperatures and pressures, is

$$T_c = K\sqrt{p_c} + x$$

in which T_c and p_c are the international physico-chemical symbols for critical temperature and pressure, and k and x are constants.

This was arrived at purely by trial and error, and undoubtedly represents the fruit of an enormous number of calculations.

Now a consideration of van der Waals' equation

$$\left(P+\frac{a}{V^2}\right)\left(V-b\right)=RT$$

leads to the following well-known relationships between p_c, T_c, R and a and b.

$$p_c=a/27b^2 \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \text{(i)}$$

$$RT_c=8a/27b \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \text{(ii)}$$

$$\text{whence } 27b^2=64a^2/R^2T_c^2 27 \quad \ldots \quad \ldots \quad \ldots \quad \text{(iii)}$$

From (i) and (iii) it follows that

$$p_c=27R^2T_c^2/64a$$

$$\text{or } T_c=\frac{8}{R}\sqrt{\frac{a}{27}p_c}$$

Now if $\sqrt{a}/R$ remains fairly constant, as is quite within the bounds of possibility, at any rate for allied elements, such as the halogens, it is clear that the equation may be written

$$T_c=K\sqrt{p_c}$$

Where K is a constant and equals $8\sqrt{a}/R\sqrt{27}$. This expression is the essential feature of Fielding's *equation. It is hardly to be anticipated that* $\sqrt{a}/R$ shall be even approximately constant for *all* the elements, and Fielding finds that there are notable exceptions. The equation holds well for hydrogen and the halogens, but oxygen and nitrogen yield divergent values. There is thus seen to be a theoretical foundation for Fielding's empirical formula, and a theoretical explanation for its very obvious limitations.

SPECIFIC HEAT OF VAPOURS.

DETERMINATION OF SPECIFIC HEAT OF A VAPOUR AT CONSTANT PRESSURE C_p.

By J. C. THOMPSON.

THE following method though not theoretically *sound is fairly correct in its result.*

Suppose 1 grm. of water at 4° C. be converted into 1 grm. of gas at 1 atmosphere pressure. This of course, is impossible as the Attractive Pressure exceeds 1 atmosphere at this density. Suppose this excess of attractive pressure to be small (or better to be compensated for in calculation at 5° C.), then the work to do this is

$$P_4 \log_e P_4 \times \frac{0{\cdot}5746}{D_4^{\frac{1}{3}}}$$

measured in atmosphere grms. D is equal to unity.

Suppose 1 grm. of water at 5° C. be converted into gas in a similar manner, then the work to do this will be

$$P_5 \log_e P_5 \times \frac{0{\cdot}5746}{D_5^{\frac{1}{3}}}$$

Now the difference between these two works converted into ergs will equal the specific heat of water in ergs from 4° to 5° less the specific heat of water vapour at constant pressure in ergs.

On calculating work at 4°, the figures 3910·059×0·5746 in atmosphere grm. centimetres and at 5° 3926·164×0·5746 are obtained.

The accuracy of these calculations is not correct to seven figures, but as regards their difference, is probably correct to six figures. The difference between these two in ergs $=2{\cdot}160\times10^7=$ Specific Heat of Water − Specific Heat of Steam $=4{\cdot}188\times10^7-2{\cdot}028\times10^7$; or Specific Heat of Steam $=\frac{2{\cdot}028}{4{\cdot}188}=0{\cdot}4843$ grm. calories; or if Specific Heat of Water from 4° to 5° is taken at 1·004 grm. calories, Specific Heat of Steam $=0{\cdot}48$ grm. calories. Experimental result at higher temperature $=0{\cdot}49$.

A Few Explanations.

(1) *Molecules do not collide, but pass sufficiently near each other to have their directions altered by the attractive forces acting between the molecules.*

The forces gravitational alone between molecules, even though the molecules be small in weight and large in size, must be great at the small distances at which the molecules are apart. A very small acceleration at right angles to the initial velocity of a molecule would prevent their collision. Or a very small velocity at right angles to the forces of attraction between two molecules would prevent the collision of molecules. Suppose collision of molecules to take place, in the gaseous state at least, before a collision takes place the molecules must have passed very close to thousands of molecules before the collision actually takes place. There is no collision between stars, and only on the assumption of very large molecules and very small forces between them can collision take place in gases. Take the first—the assumption of very large molecules compared with their distances apart. This can only be true if molecules expand on passing from liquid to gaseous state. If molecules make this big expansion, it does not seem probable that they are perfectly elastic spheres. The second assumption—that the forces of attraction between molecules is small is highly improbable. Consider water gas at 100° C. and 1 atmosphere pressure; the slightest increase of density makes the gas quite independent of external pressure; that is, there ceases to be an external pressure. On the collision theory, the collisions must still go on and be counteracted by some other force. This force must be at 100° C. be less by an infinitesimal amount than the force required to produce 1 atmosphere pressure. Which is by no means a small force compared with the weight of substance.

(2) *Molecules have no size.*—This should be rather stated that the size of molecules does not in any way influence the volume occupied by a liquid.

(3) *A liquid is a gas under its own attractive pressure.*—This is more or less accepted, together with considerable size to molecules. The pressure, of course, will vary with the size and other properties given to molecules. When a property, as Latent Heat, is related to a force that assumes no size to molecules, either the molecules have size which is also related to the Latent Heat, or they have no size. The latter assumption is far more probable. It would be as well to mention here that any change in the size of molecules is believed to be accompanied by optical and electrical phenomena, the kinetic energy of the parts of the molecule, and hence the size of the molecule bearing a similar relationship to the electrical potential, as the kinetic energy of the molecules, and hence the density of the substance does to the temperature.

Compressibility.—A liquid apart from the surface is incompressible until a pressure equal to the attractive pressure is applied.

Meniscus.—A meniscus will be formed when the attractive pressure exceeds the applied pressure.

Solubility.—Two liquids, not miscible, form a miniscus when in contact with each other. (Where ionization takes place another factor is involved).

At applied pressures exceeding the attractive pressure of the substance with highest attractive pressure, all substances are miscible. This should take place about seven miles beneath the sea-level—hence the earth's interior becomes homogeneous and doubles its density every seven miles. Also no mountain could exceed seven miles in height, unless constructed of some specially light material.

The attractive pressure of a vapour is equal and opposite to the vapour pressure at that pressure.

The surface of a liquid must be considered as being at pressures which vary from the applied pressure to the attractive pressure.

(4) A solid is a liquid in which the attractive forces of the molecules are different in different directions.

This follows directly from the theory of a liquid and explains the increase or decrease in density on solidification of a liquid.

This readily explains the hardness and elasticity of solids. It may be possible that a solid always consists of a number of minute crystals.

(5) A crystalline solid is so arranged that equal forces always act in the same direction.

The growth of a crystal from solution is explained on this hypothesis, as the molecules in separating from solution will attach themselves to the small crystal so that the greater forces act upon the greater forces.

A crystalline solid will have different attractive pressures in different directions, and hence different coefficient of expansion in different directions. A crystal, too, will have different densities in different directions. The double refraction of light in crystals points to different densities in different directions. Both the refraction of light and density depend on attractive pressure.

NOTICES OF BOOKS.

Coke-Oven and By-Product Works Chemistry. By THOMAS BIDDULPH-SMITH, F.C.S. Pp. x.+196. London: C. Griffin & Co., Ltd., Exeter Street, Strand, W.C.2. Price 21s.

The author has written this book for the guidance of the coke-oven and by-products works chemist, for the various works on chemistry applied to gas manufacture, although extremely useful, do not by a long way meet his requirements.

The contents of the book comprise the methods of sampling and analysing the coal, coke, and gas, and later in the book the sampling and analysis of the products of distillation of coal tar, for example, benzol, the estimation of xylene in solvent naphtha, &c. The author also gives chapters dealing with the working of different plants, such as the tar distillation plant, the ammonium sulphate plant.

The book contains two appendices. Appendix I. gives a *resumé* of the properties of some of the constituents of coal tar, a translation by Percy Edwin Spielmann, Ph.D., B.Sc., F.I.C., A.R.C.Sc. In this Appendix, reference to German literature and patents have been retained, in order to serve as a guide to information which may not otherwise be very readily found.

Appendix II. gives a list of data useful to the chemist working in the laboratory. The chemist or works manager working in the above industry would find this book a great help to him.

The Clayworkers' Handbook. By ALFRED B. SEARLE. Third Edition. 1921. Pp. viii+381. London: Charles Griffin & Co., Ltd, Exeter Street, Strand, W.C.2.

The whole field of clayworking is explored by the author in a very comprehensive manner. He first deals with the materials used in clayworking, namely, clay and its varieties, glazes, frits, colours, water, fuel, oils, and lubricants.

The second chapter deals with the preparation of the clay from the mining and quarying, through the intermediate stages of sorting, weathering, cleaning, grinding, mixing, and pugging.

The author in the third chapter devotes his attention to describing the machinery required for the operations enumerated above, giving methods of obviating troubles such as the formation of scale in boilers, also formulæ for the interpretation of results as, for instance, the transmission of power by belts, &c.

The chapters following this deal with different processes for the production of the finished article. Chapter XI. on "Defects" gives a list in alphabetical order of the different defects more commonly met with in clayworking, and methods for obviating same.

Chapter XIII. goes into the subject of testing and analysing the clay and clay products very thoroughly. The book ends with an Appendix of general information which will be found most useful to the clayworker.

The author is to be congratulated in collecting such a lot of valuable information and putting into such a concise and intelligible form.

A Dictionary of Chemical Terms. By JAMES F. COUCH. New York: D. van Nostrand Co. 1920. Price $2·50.

This book is designed to serve the convenience of those who have occasion to read chemical literature. New terms are continually being introduced into chemical science, and it is often difficult to arrive at a clear definition of their meanings. The treatment of the terms in the book is designed to lie between that of a standard English dictionary and that of an encyclopædia. The author, in his preface, while stating that every effort has been made to ensure accuracy, invites the fullest criticism, in order that errors may be eliminated in future editions.

The work is very well printed, and contains a fund of matter in a very small space that will be found of great value, both in schools and in the laboratory.

Principles of Wool Combing. By HOWARD PRIESTMAN. Second Edition, revised and enlarged. Pp. viii.+236. 1921. London: George Bell & Sons, Ltd. Price 12s. net.

The present new edition of this work has been thoroughly revised. Descriptions of machines that have become obsolete have been removed, and new types of machinery introduced in their place. The book is necessarily of a very technical character, but the wool industry is one of such supreme importance that an authoritative work on the principles that underlie wool combing will undoubtedly be found of great value. The book is illustrated by a great many diagrams connected with machinery used in the wool industry, and from the descriptions of operations it is evident that the author is thoroughly acquainted with the technique of the subject.

Many of the operations of wool dressing have been completely revolutionised of late years, and the author contrasts the practice in the good old days with that of the present time, which shows, even to the uninitiated, that the introduction of scientific methods is rapidly replacing the old rule of thumb practices of the past. The book is well indexed and contains nearly 100 illustrations.

First Course in General Science. By FREDERICK DELOS BARBER, A.M., MERTON LEONARD FULLER, N.D.I., M.A., JOHN LOSSEN PRICER, A.M., and HOWARD WILLIAM ADAMS, B.S. 607 pp. Fully illustrated. New York: Henry Holt & Co. London: G. Bell & Sons, Ltd. Price 9s. net.

The aim of the authors has been to present a first course in general science for the use of the high schools. The scope of the book is very general, and technicalities are carefully avoided, so that the tone of the book approaches very closely to that of Pepper's "Playbook of Metals," which is familiar to a great many of us, written at a time when science was far less general than it is at present. The approach to each new topic is made from a historical point of view, with the object of developing an interest in the subject. The earlier chapters are more or less elementary, and as the ability of the pupil grows, the work becomes progressively technical. A marked feature of the book is the immense number of original illustrations of a very varied character, but they certainly help greatly to make clear descriptions of apparatus and experiments that must of necessity be brief. We cannot help thinking, however, that the book would have been better for the omission of many of the plates. For instance, in a chapter dealing with dust and its dangers, a description is given of the vacuum cleaner, and half-a-page is taken up with a picture of a very beautiful young lady manipulating the vacuum cleaner while a gentleman is apparently having his breakfast at the same moment. There are a great many other illustrations of this type that are more suitable to a manufacturer's catalogue than to a book dealing with general science.

The line blocks of technical apparatus are very good, but the half-tone blocks are very inferior on account of the rough surface of the paper. Some of the portraits of men well known in science are very poor indeed.

There is a good Appendix at the back of the book devoted to weights and measures and the metric system, and a glossary of the terms used in the book which would be found of very great use.

Introduction to Textile Chemistry. By H. HARPER A.R.C.Sc., B Sc., A.I.C. Pp. x.+189. 1921. London: Macmillan & Co., Ltd. Price 3s. 6d.

Students thinking of taking up textile chemistry will find this small book a useful introduction to the subject. Descriptions are given of the various natural and artificial fibres used, together with the special tests and reactions for each, and definitions of the technical terms connected with their preparation or manufacture. Simple experiments are described which illustrate special points in the text. Supplementary chapters on oils and soaps, water-tests for textile fibres, and the chemicals used in textile manufacture contain a great deal of useful information. The book is completed by a series of mathematical and other tables, and a glossary of chemical terms.

Text-book of Qualitative Analysis of Inorganic Substances. By S. A. KAY, D.Sc. Pp. viii.+80. 1921. London: Gurney & Jackson. Price 7s. 6d. net.

The chief points of difference between this little book and others of a similar type are, firstly, that actual analytical procedure is described more minutely than is generally considered necessary in an introductory text-book, and secondly, that all experiments and reactions are carried out with very small quantities of materials. The author's reasons for these differences are that if the student can learn the experimental details from the book, the teacher will be able to discuss more freely with him the underlying principles upon which the procedure is based, and also that the use of small quantities of material tends towards greater accuracy in analysis as well as economy in reagents and apparatus. We are in full accord with the author's aim and wish the book every success.

CHEMICAL NOTICES FROM FOREIGN SOURCES

Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences. Vol. clxxiii., No. 12.

"Action of Emulsine of Almonds on Lactose in Ethyl Alcohol Solution at 85°. By M. Marc Bridel.

No 13.

"The Corpuscular Spectra of the Elements." By MM. Maurice and Louis de Broglie.

NOTES.

THE current number of the *Scientific American* publishes a paper by Mr. E. F. Cone, entitled, "The Divining Rod made Respectable"; an editorial note secures the *Scientific American* from any responsibility concerning the statements made, which is perhaps wise; a great deal is said about X-rays, radium radiations and the like, and then the inventor claims to have made a machine that can respond to any specific radiation said to proceed from all substances, "cartridges of the material sought for are placed in the device; the mechanism then synchronises the emanations . . . and locates the definite confines of the material in the earth," no matter how deeply they may be

buried, and as for oil fields and pockets of natural gas, it is said that a 100 per cent record was made in the location of new oil pockets or fields. It is hardly necessary to add that a company has been formed to exploit the invention.

BIRKBECK COLLEGE.—Mr. L. Bolton, winner of the £1,000 prize offered by *The Scientific American* for the best essay on "Einstein's Theory," will give two lectures on "Relativity" at Birkbeck College, Fetter Lane, E.C.4, on Mondays, October 24 and 31, at 5.30. Admission is free, without ticket.

UNIVERSITY OF BIRMINGHAM CELEBRATES ITS MAJORITY.—The University of Birmingham is just 21 years old. It is an outgrowth of the Mason Science College, founded in Edmund Street, Birmingham, by Sir Josiah Mason, the penmaker, and opened in 1880. Gradually its scope was enlarged, and it became known as the Mason University College, indicating a further advance in status, which prepared the way, under the fostering care of Mr. Joseph Chamberlain, M.P., for its expansion in 1900 under Royal Charter into a University, with its own Faculties and Degrees. The Arts and Medicine sides of the University remain in Central Birmingham, but the Applied Science and technical work is done at noble buildings at Edgbaston (three miles away), on a site of 45 acres. There are the great metallurgical and mechanical, electrical, and civil engineering blocks, as well as the departments of Chemistry and Physics, Mining, and Petroleum Technology. The unique event was celebrated by a Conversazione, which took place on Friday last at the Edgbaston University Buildings. The guests, who numbered 900, were received by Sir Gilbert Barling, Bart., the Vice-Chancellor, with whom was Mr. C. Grant Robertson, the Principal, and the Deans of various Faculties. The Lord Mayor (Alderman W. A. Cadbury), headed the Civic Representation. The seven counties surrounding the City, which constitute the sphere of influence of this great Midland University, were all represented. In the various departments, experiments were performed by the Professors and their staffs to illustrate in a limited degree the scope of the University's activities, both the teaching and research. The close alliance of science and industry was noticeable everywhere.

NOTES FROM NORWAY.—Papers read before the Physical Society of Kristiana, September 23, 1921: "The Structure of North Light and the Nature of Cosmic Rays," by L. Vegard; "Variation in the Pressure of Gases caused by Electrostatic Forces," by O. E. Trivold. Norwegian Chemical Society, Kristiana, October 3, 1921: "The Occurrence of Scandium and its Compounds," by L. Schetelig.

TRADE DEPRESSION.—The Executive Committee of the Federation of British Industries have prepared a Memorandum which has been forwarded by their President, Sir Peter Rylands, to the Prime Minister. The report, which unfortunately is too lengthy to reproduce in the CHEMICAL NEWS, deals with the problem in a very masterly manner. It first briefly outlines the causes of the present depression, discusses the restoration of stability, and suggests possible measures for alleviating the difficulties of the next few years, and other factors, the final conclusion is put so clearly, and is of such vital importance that we reproduce it in full. "We have got to realise that if we are to sell goods to an impoverished world we must sell them at a price which that world can afford to pay, and that if foreign labour costs are below ours in any trade, either through their workmen accepting lower rates of remuneration than ours, or giving higher efficiency for similar remuneration, no artificial measures will enable us to continue to give employment in that trade. The lowering of the cost of production involves of course two factors; the first is the improvement of management, organisation, and plant, and requires time, and above all, the expenditure of capital which war and present taxation and the diminution of the world's capital resources will render it extraordinarily difficult to supply. The second factor is either an increased efficiency of labour in proportion to its remuneration, or decreased remuneration without a decrease in efficiency. The choice before the country is to reach this result either by agreement which would be infinitely the quickest and most satisfactory to everyone concerned, or by sheer force of circumstances—continued unemployment, continued distress, and in the ultimate resort starvation for the workman and bankruptcy for the employer.

QUEENSLAND'S SALT LAKE.—The State of Queensland, as well as the American State of Utah, has its salt lake, and the following particulars of this natural feature of a country rich in mineral and agricultural resources, are of more than usual interest. According to Australian advices, some local operators, the Herrod Bros., of Bowie Station, brought in an interesting collection of specimens obtained on the shores of Lake Buchanan. Lake Buchanan is a salt lake situated on high country about 150 miles south-west of Pentland. The specimens are the head and bones of a bullock, which died on the shores of the lake. These bones carry deposits of salt, and the skull is encrusted in salt. As the water recedes, salt is left on the foreshores of the lake, and at present it is estimated that an expanse of twelve miles by four miles of this foreshore is exposed. This beach carries beautiful white salt of very fine grain, from 1ft. to 3ft. deep. 200 large bags of salt were obtained recently in this spot in two days. On the bones brought into town, lumps of pure salt, about 2in. or 3in. thick were encrusted, while the forehead of the skull carried 2in. of pure white salt. Given cheap carriage, there should be money in the natural salt deposits of Lake Buchanan. Wild fowl live in thousands on these waters, but the water is too salt for stock. The lake is about 32 miles long by 8 at the widest part. It is a huge oval, and in a dry time it is possible to drive across it on the salt-crusted surface. In fact, the Herrods drove a buggy and pair across it quite recently, the crust of the salt being estimated at from 8in. to 1ft. deep. A horse is usually ridden on it to test the surface. After rain, this lake is a mass of game—swans, ducks of all sorts, geese, cranes, and pelicans in droves. Pelicans nest in the small islands in this lake, in fact, these islands are havens for incubation and eggs are everywhere. There are

many swamps of fresh water quite handy to Lake Buchanan, which are full of game. The method adopted by the Herrods when collecting salt is to scoop the salt in heaps in shallow water, and then shovel it into kerosene tins which have been freely perforated. *The water drains off, and good clean* salt remains. This is a cleaner and better way than shovelling it from the foreshore where the salt contains grass and twigs, and is not so clean. Tons and tons of this salt are on the foreshores of the lake. This lake is in a mountain depression, which forms the catchment for it. It is on no watershed.

NEW COMPANIES.

The under-mentioned *particulars of New Companies recently* registered are taken from the Daily Register compiled by JORDAN & SONS, LIMITED, Company Registration Agents, Chancery Lane, W.C.2.

DANIEL VAHRMAN, LIMITED.—(177125)—Registered October 5th, 1921. To carry on the business of chemists and druggists. Nominal Capital: £1,000 in 1,000 Ordinary Shares of £1 each. Directors: D. Vahrman, 76, Brick Lane, E.1. (Governing Director and Chairman); Mrs. P. Vahrman, 76, Brick Lane, E.1. Qualification of Directors: £25. Remuneration of Directors: £500 Governing Director.

ANGLO-CONTINENTAL METALS, LIMITED.—(177066)—Registered October 1st, 1921. 5, Bishop-gate, E.C. To carry on the business of Exportors and Importers of Ferrous and Non-Ferrous Metals and Metal Products. Nominal Capital: £10,000 in 8,000 Preference Shares of £1 each, and 40,000 Ordinary Shares of 1s. each. Directors: W. M. Warman, 17, Hogarth Road, Earls Court, W.; J. W. Maidment, 17, Hogarth Road, Earls Court, W. Remuneration of Directors: To be voted by Company in General Meeting.

New Patents.

THIS List is specially compiled for the *Chemical News* by Messrs. Rayner & Co., Registered Patent Agents, of 5, Chancery Lane, London, W.C.2., from whom all information relating to Patents, Trade Marks and Designs can be obtained gratuitously.

Latest Patent Applications.

26042—Adelantodo, L.—M nufacture of superphosphates and manure. October 1.

25562—American Cellulose and Chemical Manufacturing Co. Ltd.—Treatment of cellulose derivatives. September 27.

25586—Bloxam, A. G.—Manufacture of ortho-oxy-azo dye-stuffs. September 27.

25862—Freeth, F. A.—Production of ammonium chloride and sodium carbonate. September 30.

25937—Pauling, H.—Method of transforming into sulphates metals and alloys *insoluble in sulphuric* acid. September 30.

2546?—Roucka, E.—Device for composing of changeable physical or chemical qualities or quantities. September 26.

Specifications published this Week.

140439—Nitrogen Corporation.—Production of ammonia.

145079—Krause, G. A.—Process and means for the evaporation or in insipissation of solutions, and also for effecting chemical reactions.

169247—Naef, E. E.—Manufacture of nickel and nickel salts.

169264—Audianne, P.—Apparatus for the manufacture of sulphuric anhydride.

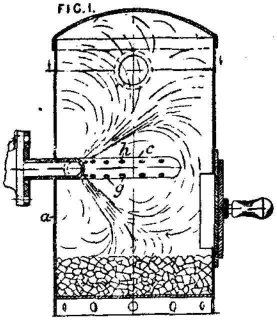
169301—Howorth, F. W.—Process for the preparation of alumina from clay.

169323—Kernot, J. C. and British Glues and Chemicals, Ltd.—Production of fertilizers.

Abstract Published this Week.

Sulphur Burners.—Patent No. 166961.—An improved sulphur burning furnace has been Patented by Mr. T. A. Clayton, of 48, Rue de la Victoire, Paris. The air for combustion is supplied in divergent streams and the air supply nozzles are arranged to leave an unobstructed passage for the introduction of sulphur. Fig. 1 shows the nozzles arranged in series *h, g*, in a hose-shaped pipe *c*, which conforms to the shape of the furnace walls *a* and leaves a central passage for the sulphur introduced from a hopper in the furnace crown. The air streams are individually regulable by a hinged valve *dl*, operated by a lever, the valve admitting air to either side of a partition *cl*, which separates the nozzles *h, g*. In a modification, a straight pipe *c*, which is disposed in the lower part

FIG. 1.



of the furnace and in proximity to a vertical furnace wall, is provided with divergent nozzles *h, g*, and regulation of the air streams is effected by a ported rotary sleeve. Partial and complete combustion are ensured by the lower and upper air streams respectively, and sublimation is consequently prevented.

Messrs. Rayner & Co., will obtain printed copies of the published specifications and will forward on post free for the official price of 1/- each.

NOTICES.

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THE CHEMICAL NEWS.
VOL. CXXIII., No. 3211.

CHEMICAL REACTIONS ON SURFACES.*

By IRVING LANGMUIR.

AFTER the discovery of the law of mass action, and its kinetic interpretation, it was at first taken for granted that the same principle would apply unaltered to heterogeneous reactions; that is, it was assumed that the reaction velocity of a substance in contact with a solid would be *proportional to the concentration of one or more of the* reacting substances. Subsequent work showed that other factors than the mere mass action effect were important in determining the velocity of these reactions.

It was shown by Noyes and Whitney (*Z. Physik. Chem.*, 1897, xxiii., 689) that the rate of solution of solid substances in liquids is often limited by the rate of diffusion of the dissolved substances away from the surface. At this surface, therefore, the solution remains practically saturated at all times.

Nernst extended this theory to cover heterogeneous *reactions in general. He assumed that* all solid surfaces were covered with adsorbed films, and that the reacting substances must diffuse through these films before coming in contact with the underlying metal or other substance, constituting the solid. He assumed that in general the rate of reaction was limited by this diffusion, and that the reaction would be practically instantaneous if it were not for the adsorbed film.

Bodenstein and Fink (*Z. physik. Chem.*, 1907, lx., 46) adopted the general features of this theory, but considered that the film varied in thickness, *depending upon the partial pressure of the gases* in contact with the solid. In this way they were able to account for cases where the reaction velocity is not proportional to the concentrations of the reacting substances. For example, it was found experimentally that the velocity of the oxidation of sulphur dioxide with a platinum catalyser, as in the "contact process", was inversely proportional to the square root of the pressure of the sulphur trioxide. They explained this by assuming that the platinum was covered by an adsorbed film of SO_3, whose thickness was proportional to the square root of the pressure of *this component.*

Although this theory suggests a possible mechanism for the effect of catalytic poisons, it has not proved to be a satisfactory general theory of catalytic action. Thus, there is no logical reason for assuming, in some reactions, that the adsorbed film is proportional to the square root of the pressure, while in other reactions, it is proportional to the first power of the pressure.

These theories of diffusion through films require the existence of films relatively thick in proportion to the dimensions of molecules, for we find experimentally that the reaction velocities can vary a thousand, if not a millionfold, in reactions when we have to account for this change by a variation in the thickness of a film. In such cases it would be necessary to have films *so thick* that we should be able to see them. Fink, however, measured the amount of SO_3 adsorbed by the platinum per unit area, and found it to be of the order of magnitude of a single layer of molecules. It is, then, hardly logical to assume that the thickness of this film can vary in proportion with the square root of the pressure for a wide range of pressures.

Evidence for the Existence of very Stable Adsorbed Films.—Experiments which the writer began in 1912 showed that the effect of residual gases on the electron emission from heated tungsten filaments in vacuum was generally to decrease the emission, instead of to increase it. Oxygen, or traces of water vapour, had a really remarkable effect in decreasing the current. Thus, at temperatures of about 1900° K., the emission was decreased many thousandfold by pressures of oxygen as low as one bar (one dyne per square centimetre, or approximately 10^{-6} atmospheres). *It did not seem possible that the* oxygen could prevent the emission of the electrons unless it covered in some form the larger part of the surface. This film, however, must have been an extraordinarily stable one, to remain on a filament in such good vacuum at this high temperature. At temperatures even as low as 1000° K. no visible film is formed on the surface of tungsten by introducing oxygen, for the WO_3 which is produced distils off and leaves the surface apparently clean.

Since that time a long series of investigations has been made on the effect of low pressures of *oxygen in altering the properties of tungsten at* high temperatures. All of this work confirms the view that even at the highest temperatures, in the presence of traces of oxygen, the surface of the filament is practically completely covered with a film of oxygen.

Thus, when the filament is heated to 3300° K. and a pressure of oxygen of a few bars is admitted to the bulb, the rate of disappearance of the oxygen shows that about 50 per cent of all the oxygen molecules which strike the filament react with it to form WO_3, which distils on to the bulb. Since there are three atoms of oxygen in the molecule of this compound and only *two in the oxygen* molecule, it is clear that *at least one-half* of the tungsten surface, even at this high temperature, must be covered with oxygen in some form.

The chemical effects of this adsorbed oxygen film are as striking as the effects on the electron emission. If a tungsten filament is heated to 1500° K., or more, in pure, dry hydrogen at low pressure, the hydrogen is gradually dissociated into atoms and the atomic hydrogen is adsorbed by the glass walls of the vessel or reacts with any WO_3 which may previously have been distilled on to the bulb. The hydrogen pressure therefore gradually decreases. The effect is entirely prevented by minute traces of oxygen. Thus, if a mixture of oxygen and hydrogen be introduced into a bulb and the filament heated to 1500°, instead of the gases reacting to form water vapour, as they would, in contact with a platinum filament, the oxygen reacts gradually with the tungsten to form WO_3. While this is going on, the dissociation of the hydrogen by the filament is entirely prevented, so that finally nearly pure hydrogen remains and the pressure remains constant. After ten or fifteen minutes the pressure

* A Paper read before the Faraday Society.

of the oxygen decreases to such a point (a minute fraction of one bar) that it no longer is able to prevent the dissociation of the hydrogen. This, then begins *suddenly* to dissociate, and in a few minutes more all of the hydrogen has disappeared.

The oxygen film on the tungsten surface thus consists of oxygen in a form which cannot react with hydrogen even at 1500°. It certainly does not behave like a layer of either tungsten oxide or of highly compressed oxygen gas. Its chemical properties have been completely modified by its adsorption on the tungsten.

The function of the oxygen in preventing the dissociation of the hydrogen is clearly that of a *catalytic poison*. This effect of the oxygen on tungsten is observed with several other reactions. For example, methane is decomposed by tungsten, giving hydrogen, while the carbon is taken up by the tungsten filament, but if the methane is mixed with oxygen, it is not decomposed until all the oxygen has reacted with the tungsten to form WO_3, and it is then decomposed as though no oxygen had been present. The same thing happens with ammonia, which, alone, is decomposed easily by a tungsten filament at 900° K., but in presence of oxygen is not decomposed unless the filament temperature is raised above about 1300° K.

If the electron emission is measured while a mixture of hydrogen and oxygen is in contact with the filament, it is found that the electron emission increases suddenly at the same instant that the dissociation of the hydrogen begins.

The remarkable stability of these oxygen films, as well as the complete change in the chemical properties of the oxygen, gives reason for believing that the surface is covered with individual oxygen atoms chemically combined with the underlying tungsten atoms. This film cannot be regarded as consisting of an oxide of tungsten, nor as atomic oxygen, in the sense in which we think of free oxygen atoms. The oxygen atoms are probably held to the surface by four pairs of electrons, just as the oxygen atom is held to the carbon atom in CO_2. The oxygen atoms are thus chemically saturated, but the tungsten atoms are not saturated, so that they are held by strong forces to the tungsten atoms that lie below them. This kind of structure is quite in accord with the conception of the structure of solids to which we are led by the work of the Braggs, on crystal structure.

Work with other metals has shown that stable films of the kind we have just been discussing are of very common occurrence. Oxygen forms a similar film on carbon, and carbon monoxide, hydrogen cyanogen, hydrogen sulphide, phosphine, and arsine form stable films on platinum. It is probable that all substances that have a poisoning effect on catalytic surfaces form films of this kind.

Evidence that these Stable Films are Mono-molecular and that the Molecules tend to be Oriented on the Surface.—According to our present conceptions, atoms consist of electrons arranged in space about a positively charged nucleus. Whether we assume that the electrons are moving or not, it is certain that the electrons nearly completely surround the nucleus. In most molecules, atoms share pairs of electrons (duplets) with each other. In any electrically neutral molecule, the field of force must decrease in intensity with a very high power of the distance from the centre. Born has calculated that the electric force around a group of eight electrons, arranged at the corners of a cube and surrounding a nucleus having an equivalent charge, is inversely proportional to the tenth power of the distance from the nucleus. Debye, from an entirely different viewpoint, reaches the conclusion that the force of attraction between molecules is inversely proportional to the eighth power of the distance between them. From considerations of this kind, it can be shown that the electric force near the surface of an atom must decrease from a maximum value at the surface to a value one-half as great within a distance of about $0{\cdot}3 \times 10^{-8}$ cm. In fact, an analysis of Debye's and other data shows that this force decreases in about the same way on receding from the surface of the atom, for molecules, of widely differing type. In other words, this distance of $0{\cdot}3 \times 10^{-8}$ is a nearly universal constant, and in this way we get a much better conception of actual conditions close to the surface of an atom than by assuming that the force decreases with the power of the distance.

If magnetic forces exist within the atom it can be readily calculated that these forces must decrease even more rapidly as the distance from the atom increases.

It must be said, therefore, that our present conception of the structure of atoms and molecules makes it impossible for us to conceive of any appreciable force which one atom or molecule can exert directly on others at distances greater than two or three Ångstrom units (10^{-8} cm.). Where effects are transmitted to greater distances than these, it must be the result of a transmission through and by atoms or molecules of matter. In view of the structure of atoms from positive and negative particles, it is clear that atoms should have the properties of a dielectric. Thus, if we have a chain of atoms linked together by duplets—as, for example, in the hydrocarbon chain of an organic compound—and we bring a positively charged body near one end of the chain, the electrons will be attracted and the nuclei repelled, so that a certain displacement of these particles with respect to one another will result. This effect is then transmitted with gradually decreasing intensity from atom to atom throughout the length of the chain, resulting in an accumulation of positive charge at the opposite end of the chain. The chemical evidence indicates clearly that effects of this kind are sometimes transmitted relatively great distances. The many facts which have led some chemists to assume polar valences, such as directed valences in organic compounds, receive a simple explanation on the basis of these transmitted effects.

In cases where atoms are not joined firmly to one another by the sharing of duplets, we should never expect the transmission of electric force to extend through more than about one atom. On this basis, we are led to deny the existence of thick, stable, adsorbed films of gas molecules such as those which were assumed in the Nernst and in the Bodenstein-Fink theory of heterogeneous reactions. If, for example, a surface is covered with a layer of oxygen *molecules*, then there should be little, if any more tendency for other molecules to form a second layer than there

would be for these molecules to remain in the surface of liquid oxygen at the same temperature. Thus, only when we have nearly saturated vapours should we ever obtain films of gas molecules which exceed monomolecular thickness.

The general opinion among colloid chemists and others who have worked with adsorption effects, at least up to a few years ago, seems to have been that adsorbed films were usually of a thickness of 100 to 1000 A. According to the views we have reached here, such thick films cannot be regarded as the result of true adsorption, but can result only from condensation in capillary spaces in presence of nearly saturated vapours or are due to sorption or solution. For example, it can be shown that glass, just like glue, can sorb large quantities of water vapour, but this is a real penetration of the water molecules into the solid material and is not a strictly surface action.

There is no good reason for believing that it is only at low pressures and high temperatures that adsorbed films are of monomolecular thickness. The effect of catalytic poisons (as studied for example, by Faraday), surface tension effects, the lubricating properties of thin oil films, passivity phenomena in electrochemical actions, electrolytic overvoltage, &c., all point unmistakably to the existence at atmospheric pressure of stable films quite analogous to those observed in high vacuum and at high temperatures.

Lord Rayleigh, in 1899, on the basis of some beautiful experiments on surface tension, showed that the film of olive oil on water contaminated with this substance has a thickness of 10 A., and is therefore probably of monomolecular thickness. This work was later extended by Devaux, Labrouste, and others. These results were of particular interest to the writer, because of their important bearing on the question of the range of atomic and molecular forces and the structure of adsorbed films in general.

Experimental results on the spreading of oils on water surfaces have completely confirmed the views outlined above. The only oils which spread on water are those whose molecules have active groups, such as the —COOH, —OH, &c., which normally increase the solubility of a substance in water. The spreading therefore occurs because the active group has an affinity for water, while the hydrocarbon chain tends to remain in contact with other chains of the same kind. The molecules on the surface must, therefore be *oriented*, so that the actual surface consists of the hydrocarbon part of the molecules, while the active groups are all turned downward towards the surface of the water. It is evident that if we have a series of substances having the same active group, but different lengths of hydrocarbon chain, the number of molecules per unit area in the oil film should remain about constant, while the length of the molecule in the vertical direction, and therefore the thickness of the film, should increase in proportion to the length of the hydrocarbon chain. Numerous experiments have completely verified these theoretical deductions (Langmuir, *Met. Chem. Eng.*, 1916, xv., 468; *Jour. Amer. Chem. Soc.*, 1917, xxxix., 1848. A brief summary was published in *Trans. Faraday Society*, 1920, xv., 1). In this way it becomes possible to measure the lengths and cross-sections of the molecules of oil films on surfaces, and to prove conclusively that the films are not only monomolecular, but that orientation of the molecules is a factor of vital importance in their formation. Very accurate measurements of the forces involved in the formation of these films and valuable additional information in regard to their structural changes have recently been obtained in England by N. K. Adam (*Proc. Roy. Soc.*, 1921, xcix., 336).

Evidence that surface films are monomolecular and that the molecules are oriented is also obtained from surface tension data on pure liquids. While the spreading of oil films on water depends upon the most active group in the molecule, the surface tension of a liquid—which is a measure of the potential energy of its surface—depends primarily on the least active group in the molecule, for the group with the lowest stray field of force will tend to form the actual surface layer, in order to make the potential energy a minimum. An analysis of practically all available published data on surface tension leads to a verification of this hypothesis.

The interfacial surface tension between two liquids, such as water and mercury, or water and oil, gives, as W. B. Hardy has shown, a measure of the energy changes involved in the formation of the interface. W. D. Harkins (*Jour. Amer. Chem. Soc.*, 1917, xxxix., 354, 541) has made numerous measurements of interfacial surface tensions which show that the work done in the formation of such interfaces is a measure of the activity of the most active part of the molecule, for the molecules become oriented at the interface.

A fourth method of determining the thickness of surface films and proving that they are oriented in the surface, depends upon the use of Gibb's thermodynamic equation, giving the total amount of material adsorbed in the surface of a solution in terms of the change in the surface tension of the solution as the concentration of the solute is altered. By measuring the surface tension of solutions at various concentrations it is thus possible to determine the amount of material adsorbed per unit area. As the concentration is increased, the amount adsorbed increases and approaches a definite limit. The results show that in all such cases the maximum amount adsorbed corresponds to that in a monomolecular film. It is thus possible to determine the number of molecules adsorbed per unit area and thus find the cross-section of the molecules. The length is then obtained from the known volume of the film. This method is applicable to adsorbed films on liquids formed either from substances dissolved in the liquids, or from substances present as vapour above the liquid. When a solution has a lower surface tension than the pure solvent, the surface has a monomolecular film of the dissolved substance, but where the solution has a higher surface tension than the solvent the surface of the solution consists of a monomolecular film containing nothing but pure solvent.

Direct experiments have also been made by the writer to determine the maximum amount of gases that can be adsorbed by plane surfaces of glass, mica, and platinum (*Jour. Amer. Chem. Soc.*, 1918, xl., 1361). At ordinary temperatures with pressures of nitrogen, hydrogen, argon, carbon dioxide, &c., up to a few hundred bars, at

least, there is no measurable adsorption by glass or mica—that is, less than 1 per cent of the surface is covered by a single layer of molecules. At the temperature of liquid air, however, and at pressures of the order of a hundred bars, the surfaces become saturated by an adsorbed film which never exceeds one molecule in thickness. The evidence is that these films consist of *molecules* and that primary valences are not involved in their formation. The forces involved are unquestionably the result of the stray field of force around the molecule, and involve no radical rearrangement of the electrons. The forces are probably very much like those involved in the formation of substances containing water of crystallisation or ammonia of crystallisation.

With a clean platinum surface which had been made catalytically active by bringing it into contact with a mixture of oxygen and hydrogen at low pressures, at a temperature of about 300° C., the adsorption phenomena were totally different from those observed with glass and mica, at least in the case of the gases hydrogen, oxygen, and carbon monoxide. When small amounts of oxygen were allowed to come in contact with the platinum surface, the oxygen disappeared almost instantly, until the total amount adsorbed corresponded to a monomolecular or monatomic film, and then no further amount of this gas could be adsorbed, even with a great increase in pressure. No trace of the oxygen could be pumped off by heating the platinum in the best vacuum to 360°.

If the platinum in this condition was allowed to come in contact with hydrogen or carbon monoxide at low pressure, the oxygen film was removed and water vapour or carbon dioxide was produced, even at room temperature, and then an additional amount of hydrogen or carbon monoxide was adsorbed sufficient to produce a monomolecular film of these substances. The carbon monoxide film could be very gradually pumped off at a temperature above 300°. No measurable amounts of nitrogen or carbon dioxide were adsorbed by the platinum at any time.

These remarkably stable films on the platinum surface are of the same type as the oxygen films adsorbed on tungsten surfaces. Primary valences are unquestionably involved in their formation. In the case of the carbon monoxide, the carbon atom must be directly attached to the platinum, while the oxygen is thus above the carbon. The carbon monoxide molecules—if we can so speak of them—are thus oriented on the surface, very much as the molecules in an oil film. The experiments with platinum give a direct proof that these stable films are of monomolecular thickness.

The evidence for the existence of monomolecular films is thus by no means confined to experiments at low pressures for equally striking evidence furnished by the surface tension phenomena. The orientation of molecules in surface layers follows as a necessary result from the conclusion that the range of atomic and molecular forces is of the order of 1 Å. The orientation in surface films is a phenomenon with which we must constantly reckon, just as we must consider structural relationships in the molecules of organic compounds. Of course, there are cases where the adsorbed film consists of single atoms, or of various symmetrical molecules, such as CH_4 or CCl_4, where we do not need to consider orientation. But wherever different parts of the surface of a molecule may be assumed to have different properties, we must take into account the probability of orientation in all adsorption phenomena and therefore in all catalytic actions on surfaces.

Mechanism of Adsorption.—We have discussed the structure of adsorbed films and the forces involved. Let us now consider the mechanism by which these films form on a surface or disappear from the surface.

When the adsorbed film of carbon monoxide on platinum gradually disappears, on heating the metal to 300° in the highest vacuum, it is logical to look upon this as an evaporation process. When a filament of platinum, or tungsten, or other metal is heated to a sufficiently high temperature in vacuum the material evaporates. If the metal is placed in a uniformly heated enclosure, the evaporation from the surface—which we may consider continues unchanged—will be gradually offset by the return of atoms of metal from the vapour which accumulates in the space. Finally, an equilibrium is reached in which the rate of condensation of the vapour is equal to the rate of evaporation.

If we can assume that all the atoms of the vapour which strike the surface of the metal condense on the first collision, we may calculate the rate of condensation from the vapour pressure by means of the kinetic theory of gases. The formula usually given for the rate of effusion of gases through small openings can readily be put in the form

$$m = \sqrt{\frac{M}{2\pi RT}}p$$

where M is the molecular weight of the vapour, R is the gas constant, p is the pressure of the vapour, and m is the rate at which the gas molecules strike against the surface, in grms. of vapour per square centimetre per second. Expressing p in bars, and placing $R=83\cdot15\times10^6$ ergs per degree, this reduces to

$$m = 43\cdot74 \times 10^{-6}\sqrt{\frac{M}{T}}p.$$

This equation gives the rate at which the molecules of a vapour strike against the surface. If every molecule condenses, and if we have equilibrium, then the rate of evaporation must also be given by this equation, so that we obtain a direct relation between the vapour pressure of a substance and its rate of evaporation in perfect vacuum.

Experiments with many different metals have shown close agreement between the vapour pressures determined in this way from the rate of evaporation and the vapour pressures measured by processes which involve the formation of saturated vapours. Knudsen has made careful experiments of this kind with mercury vapour, while A. S. Egerton (*Phil. Mag.*, 1917, xxxiii., 33) has carried out work with cadmium and zinc. Their results indicate that every atom of vapour condenses

Knudsen and R. W. Wood independently arrived at the conclusion that mercury or cadmium atoms condensed on a glass surface only if this surface is cooled below a certain critical temperature. Below this temperature, practically

every atom is supposed to condense, while at temperatures materially above this critical point not one atom, out of thousands which strike the surface, condenses. This conclusion is not only inherently improbable in many ways, but it not capable of accounting for numerous experimental facts. Wood's and Knudsen's experiments are better explained by assuming that all the atoms of cadmium and mercury which strike a glass surface even at high temperature, condense on the surface, but that at temperatures above the "critical temperature," the atoms re-evaporate before they have a chance to be struck by other atoms of the vapour. The writer has discussed this question in detail in a paper in the *Physical Review*, 1916, viii., 149, and subsequently carried on experiments with cadmium vapour (*Proc. Nat. Acad. Sci.*, 1917, iii., 141) which demonstrate conclusively that cadmium atoms evaporate rapidly from a clean glass surface at room temperature. There is no real reason for believing that cadmium may not also evaporate from glass at temperatures only slightly above the critical temperature of $-90°$ C. cited by Wood. Since molten cadmium does not wet glass it is clear that the forces between a cadmium atom and a glass surface are much less than between cadmium atoms, and the rate of evaporation should therefore be much higher.

In most cases of adsorption we are dealing with a solid surface having a strong field of force, or a high potential energy per unit area, while on this solid is condensed a substance whose molecules possess a rather weak stray field of force. These are the conditions when ordinary gases condense on cooled surfaces of glass or metals. The forces which might tend to hold a second layer of molecules are so weak that evaporation from the second layer occurs at a rate high compared with that from the first. Only with nearly saturated vapours, then, can a second layer form.

With cadmium and mercury vapours condensing on glass, however, we have a case in which the evaporation from the second layer takes place much more slowly than from the second layer. We see, therefore, that a kind of instability necessarily results. There is considerable difficulty in getting the first layer to form, because the atoms tend to evaporate before the others are able to condense on top of them or beside them. If the first layer ever does form, then the evaporation practically ceases and successive layers are then formed with ease. This view seems to give a clear picture of the mechanism of the formation of nuclei on which condensation occurs. The formation of frost crystals on a greasy window-pane, or Moser's breath figures on glass, are illustrations of effects of this kind.

We might suppose that when molecules of a gas strike a surface, only a certain fraction a condense on the surface, while the others are reflected. Experimentally, however, it seems hard to find examples where a is appreciably different from unity. Soddy, Knudsen, and others have found, however, that in heat conduction from a solid surface to a gas at low pressure, the gas molecules which strike the surface do not always reach thermal equilibrium with the surface before leaving it. Knudsen has given the name "accommodation coefficient" to the fraction which expresses the actual heat conduction to that calculated on the assumption of heat equilibrium. It is to be noted, however, that these coefficients are usually of the order of magnitude of 0·8, and they are determined under conditions in which the rate of evaporation of the gas from the surface is unusually high. We should probably, therefore, look upon these as rather exceptional cases, and, unless we have definite evidence to the contrary, should assume that the coefficient a is unity.

When gas molecules of any kind strike a surface, we should therefore not expect them to rebound elastically, but rather expect them to condense. Adsorption is thus the result of the time lag between condensation and evaporation. In some cases the rate of evaporation is so low that evaporation practically never occurs. This is what happens, for example, when a catalyst is poisoned by sulphur or arsenic compounds. In other cases, the rate of evaporation may be so high that the time that elapses between condensation and evaporation may be of the order of 10^{-13} seconds or even less.

The Mechanism of Chemical Reactions on Surfaces.—The clean surface of a solid crystalline body must consist of atoms or molecules arranged in a surface lattice, or kind of checkerboard. Non-crystalline bodies, such as glass, must have surfaces in which the atoms are probably not in regular lattices. We may also have surfaces which are porous, or consist of irregular filamentary projections and interlocking chains of atoms or molecules. In such cases the extent of the surface cannot be defined, except in a purely arbitrary manner. Most finely divided catalysts, such as platinum black, or activated charcoal, &c., must have structures of great complexity, and it is probable that the atoms are attached to each other in the form of branching chains so that there are hardly any groups of as little as three or four atoms which are as closely packed as they would be in the crystalline solid. In order to simplify our theoretical consideration of reactions on surfaces, let us confine our attention mainly to reactions on plane surfaces. If the principles in this case are well understood, it should then be possible to extend the theory to the case of porous bodies.

In general, we should look upon the surface of a catalyst as consisting of a checkerboard in which some of the spaces are vacant, while others are filled with atoms or molecules. Some of these molecules, or atoms, may be so firmly attached that they do not evaporate at an appreciable rate. Others leave the surface from time to time, and the vacant spaces thus left are sooner or later filled by other molecules which strike the surface and condense.

If we have a surface such as that of platinum, and we allow to come in contact with it a gas, which forms an adsorbed film that evaporates slowly, or not at all, the surface is no longer a platinum surface as far as possible interaction with other gas molecules is concerned. The catalytic activity of the platinum has thus been lost, or the catalyst has been poisoned. Arsenic, sulphur, or phosphorus compounds have this effect, for the atoms of these elements presumably combine directly with the atoms of the platinum and do not evaporate at an appreciable rate. Cyanogen and carbon monoxide have a similar, but more transient effect on platinum, only as

long as these gases remain present in the gas phase does the poisoning influence persist.

Faraday studied the effect of various substances in poisoning the catalytic activity of platinum on the reaction between oxygen and hydrogen. By boiling platinum foil in concentrated sulphuric acid, and then washing with distilled water, it is brought into a condition where it brings about the combination of oxygen and hydrogen at room temperature. The presence of carbon dioxide did not retard this action, but a trace of carbon monoxide stopped the action entirely, although on placing the platinum in a mixture of fresh gas, free from monoxide, the reaction proceeded in a normal manner. Hydrogen sulphide, or arsine, not only prevented the action while they were present, but produced a permanent alteration in the platinum, so that it was necessary to boil it again in acid before it could be made active. The poisoning effect of oxygen on the catalytic activity of tungsten at high temperature is of the transient kind produced by carbon monoxide on platinum.

In the presence of a gas which has a poisoning effect on a catalyst, the reaction velocity depends on that fraction of the surface which is *not* covered by molecules of this gas. If the temperature is high enough and the catalyst poison is of the kind that has a transient effect, the adsorbed molecules evaporate at a certain rate. If much of the gas is present, the vacant spaces thus produced tend to be refilled by these molecules. The fraction of the surface which is in an active condition is thus directly proportional to the rate of evaporation of the film, and inversely proportional to the partial pressure of the gas producing the poisoning effect. We are thus led to an understanding of the mechanism of the type of reaction which was explained by Bodenstein and Fink by assuming adsorbed films having a thickness varying in proportion to the pressure of the gas.

When gas molecules condense on a solid surface in such a way that they are held on the surface by primary valence forces, involving a rearrangement of their electrons, their chemical properties become completely modified. It is not surprising, therefore, that in some cases such adsorbed films should be extremely reactive, while in other cases they may be very inert to outside influences. Thus oxygen adsorbed on platinum reacts readily with hydrogen or carbon monoxide, while oxygen on tungsten, or carbon monoxide on platinum, show very little tendency to react with gases brought into contact with their surfaces. The specific nature of the behaviour of these various films is quite consistent with the theory that the adsorption depends on typical chemical action. In many cases, especially where we deal with adsorption of large molecules, the orientation of the molecules on the surface is a factor of vital importance in determining the activity of the surface towards reacting gases.

The reaction which takes place at the surface of a catalyst may occur by interaction between molecules or atoms adsorbed in adjacent spaces on the surface, or it may occur between an adsorbed film and the atoms of the underlying solid, or again, it may take place directly as a result of a collision between a gas molecule and an adsorbed molecule or atom on the surface. This third kind of action is perhaps indistinguishable from one in which the incident gas molecules condense on top of those already on the surface, and then react with them before they have a chance to evaporate.

When a surface is covered by different kinds of adsorbed molecules distributed at random over the surface, we may expect in general that adsorbed molecules in adjacent spaces should be able to react with one another at a rate which is proportional to the chance that the given molecules shall lie in adjacent spaces. This kind of mechanism has been discussed at length by the writer in connection with a study of the dissociation of hydrogen in contact with a tungsten filament (*Jour. Amer. Chem. Soc.*, 1916, xxxviii., 1145). When the hydrogen molecule strikes a tungsten surface at high temperature, at least 68 per cent of the molecules condense on the surface and are held there as individual atoms. After the action has proceeded for a time, the distribution of atomic hydrogen over the surface is given by the probability laws.

(To be continued).

THE NEW INTERNATIONAL COMMISSION ON CHEMICAL ELEMENTS.

Remarks by Prof. BOHUSLAV BRAUNER, Ph.D., Hon.D.Sc.(Manc.)

THE report of the meeting of the International Conference of Pure and Applied Chemistry, held at Brussels at the end of June, published in *Nature* of August 18 (p. 787), contains the following statement: "It was felt that the exact determination of atomic weights and their publication to several places of decimals has now *lost a good deal of its scientific signification* in view of the work of Dr. Aston and others, and that exact *atomic weights are now becoming factors of analytical calculation rather than features of a chemical analysis* . . . . The atomic weights—often representing merely the average mixture of isotopes—will be of practical rather than theoretical interest, &c."

The official report, which I obtained as a member of the new "International Commission on Chemical Elements" (consisting of two Honorary Presidents and seven Members) sounds a little differently. According to it, Sir William Pope remarked that "work of all kinds is modifying the fundamental notion of the chemical element, and so the constitution (establishment) of the Table of Atomic Weights does not present the same interest as it presented at the epoch when atomic weights were regarded as absolute constants." Therefore, a new Commission, with a larger programme (Table of Radioactive elements, isotopes, and atomic masses) was proposed and really constituted.

Every chemist will undoubtedly agree with Sir W. Pope, and will welcome his proposition and the formation of the new Commission. On the other hand, it does not seem possible for me to accept the principle, as reported in *Nature*, especially that "exact atomic weights are now becoming factors of an analytical calculation rather than features of a chemical hypothesis."

I beg to remark that we know to-day two kinds of isotopes, which we may call A and B. The

isotopes A are either radioactive elements (heads) or *products of the same or different series of* radioactive disintegration, Soddy's isotopes. The isotopes B, J. J. Thomson's and Aston's isotopes, represent mixtures of extremely similar elements, which were formerly regarded as one individual element.

The isotopes A descend from U or Th down to the isotopes of Tl, and the different series end in "leads" of the atomic weights 206 and 208, but all isotopes representing one place do not necessarily occur together at the same time, *e.g.*, the 7 or 8 isotopes of lead (Moseley's atomic number 82).

The isotopes B, as far as we know, *always* occur in nature together, and *always* in the same proportions, their mixture yielding *always* the same average *combining weight*. Dr. Aston has shown that they can be separated from their mixtures by suitable electro-magnetic analysis and that their *atomic masses* are represented by integers (O=16, which standard was recommended for the first time *with success* by the writer in CHEMICAL NEWS, 1888, lviii., 307). They go to-day from H up to Cs.

Dr. Aston has shown that, besides the mixtures of isotopes also *pure elements* exist. Their atomic *masses* are also integers, their *atomic weights* as determined by the most able human hands by means of the *balance* show in the majority small, but real deviations from integers.

We know up to the present the following "pure" elements: H=1·008, He=4·00, C=12·005, N=14·008, O=16·000..., F=19·00, Na=23·00, P=31·04, S=32·06, As=74·96, I=126·92, Cs=132·81 (?). These are their *atomic weights*, which we must not confound with their *atomic masses*: 4, 12, 14, 16, 19, 23, 31, 32, 75, 127, and 133.

As regards the question, what theoretical interest present our atomic weights, it must be admitted that the original form of the Periodic Law, as given by Mendeléef in 1871: "The properties of elements, etc., are periodic functions of their atomic weights" had to be changed as soon as it was definitely proposed by the writer that the "combining weight" of tellurium is higher than that of iodine, and, in fact, it was also pointed out that our tellurium cannot be a simple substance of a homogeneous body, for, if such an *element* possessed the high *atomic weight* (Te=127·6, I=126·9) "the Periodic Law would lose a great deal, if not all, of its authority" (*Chem. Soc. Trans.*, 1889, lv., 706, 709). On the contrary, it was assumed that "tellurium with the combining weight of 127·6 is a true 'gadolinium' of the hydrogen sulphide group," *i.e.*, an inseparable mixture of very similar elements. I regret that Dr. Aston has not yet succeeded in proving it.

We also know to-day, that owing to the anomalies Te>I, Co>Ni, and A>K, as well as owing to the discovery of the isotopes and, as pointed out by the author about the series of 13 rare-earth elements, from Pr=140·9 up to Lu=175·0, the properties, etc., of which are *not* periodic functions of their atomic weight (see Abegg's "Handbuch III., i., pp. 171, 261, 275, 283, 304) the properties of elements and their compounds (except those of the rare-earths) are functions of Moseley's or atomic numbers. But I would beg to add that the original formulation of Mendeléef's Periodic Law is not entirely invalid, and that the properties of the *pure* elements, *i.e.*, of those which do not possess any isotopes, are still *periodic functions of their atomic weights. It is* true that since the discovery of isotopes, the constitution of the Table of Atomic Weights does not present the *same* interest as it presented at the epoch when atomic weights were regarded as absolute constants, but some of the numbers have gained a fresh theoretical interest, as I would like to prove.

Our elementary atoms are peculiar condensations of hydrogen nuclei (protons or positive electrons) or helium nuclei, which are in their turn again condensation of hydrogen nuclei, and probably also of H_3 nuclei and of electrons.

As regards the mechanical masses of the inner and the outer negative electrons in the atoms, it is a question whether they possess any mass at all, considering that their position in the atoms is rather stationary and under quite different conditions from those under which their *electro-magnetic mass* was determined (*i.e.*, from their rapid motion in cathode rays). At least the fact, that Aston's *atomic masses* are integers, would rather show that the masses of electrons are negligible.

Now the question arises: why do we find with our chemical processes and the balance that the *atomic weights* of the *pure* elements C, N, P, S, are *larger* than their *atomic masses*, why those of As, I, and Cs are *smaller* and why those of He, O, F, Na, are exactly equal to their *atomic masses*, or in other words, why is the hypothesis of Prout in its modern form valid for atomic masses but only in four out of twelve cases for the corresponding atomic *weights*? Another interesting question arises: why are Aston's isotopes B, as far as we know, always mixed up in the same proportion?

I do not think that, say only an American chemist might find the *combining weight* (average atomic weight) of chlorine 35·46 and of silver 107·88, and that an Australian may find from another material occurring in nature Cl=35·1, and Ag=107·5, as some chemists seem to be afraid of. I might only remind them of the experiments of Harkins, who, after many troublesome processes effected only a slight separation of the isotopes of chlorine. And if such a difference should be found one day, it will require the work and authority of an experienced chemist, who has formerly made reliable, exact atomic weight determinations to prove that such a great and sensational discovery was really made.

Readers of the CHEMICAL NEWS have undoubtedly perused the most interesting Presidential Address given by Sir T. E. Thorpe to the recent meeting of the British Association at Edinburgh, in which the modern views on atoms, &c., were discussed (CHEMICAL NEWS, Sept. 9 and 16, 1921). I am very glad to find the following passage: "The term 'atomic weight' has thus acquired for the chemist an altogether *new and much wider significance.* It has long been recognised that it has a far deeper import than as a *constant useful in chemical arithmetics*" and further that he recommends to "determine with the highest attainable accuracy the departures from the whole number rule."

I quote those few words of an authority possessing great experience in questions regarding atomic weights, with great pleasure and satisfaction, for they show that my opposition to the views quoted at the beginning of this article is not unfounded.

I beg to conclude with an historical reminiscence. *J. S. Stas, who was originally an adherent of the* hypothesis of Dr. Prout (1815), concluded from his own work, published in 1860-1865, that it is untenable because the atomic weight of the 11 elements cannot be expressed by a whole number, and the atomic weight of chlorine, Cl = 35·457 (O = 16) is far from being a multiple of 1 or 0·5 or 0·25 as might be expected from the point of view of Dumas' modification of Prout's hypothesis. Stas declares the latter as "a pure illusion."

A great contemporary of Stas, Charles de Marignac, another great authority in atomic *weight determinations, has shown* ("Œuvres Complètes," I., 1860, 693; II., 1865, 281), that it cannot be due to a mere chance that eight out of nine atomic weights determined by Stas differ from whole numbers only by ±0·068, instead of about ±0·5, as expected by the calculus of probability. Marignac points out that the fundamental principle which led Prout to establish his law, ***the idea of the unity of matter***, is something higher than the search for the common division of the atomic weights, and he adds the following prophetic words (I., 701): "Could we not suppose that the cause, unknown but probably different *from the chemical and physical agencies*, which has determined certain groupings of the atoms of the unique primordial matter in such a manner as to give birth to our simple chemical atoms, and to impress to each of these groups a special character and particular properties, could at the same time exercise an influence upon the manner according to which these groups of atoms obey the law of universal attraction, of such a kind ***that the weight of each of them is not exactly the sum of the primordial atoms which constitute it?***

A still more decided belief in the compound nature of our elements was expressed by Marignac *in a public lecture given by him* in Geneva in January, 1866, "Sur l'hypothèse de l'unité de la matière," and published only recently by Ph. A. Guge in his *Journ. Chim. Phys.*, J. 18, No. 3, October, 1920.

Mendeléef, who never admitted that his Periodic System points to the unity of matter, expressed in spite of this in his classical paper on the Periodic Law (*Ann. Supl.*, Bd. 8, 1871) a similar idea. Even if we admit that the matter of the "elements is perfectly uniform (homogeneous), there is ***no reason to assume that n-parts by weight*** of one element or of *n*-atoms, in the case of a transmutation into the atom of another element ***will be n-times heavier than that of the first one.*** The law of the conservation of weight can be regarded as a special case of the conservation of energy or of motions. The weight is probably caused by a peculiar motion of matter and there is no reason to refuse the possibility of the conversion of these movements in the case of a formation of elementary atoms into chemical energy or into another form of motion."

Both these great chemists have predicted what we accept to-day that $4 \times 1·008 + (2e \text{ inner}) + 2e \text{ outer}) = 4·00 = \text{He}$. I may be allowed to remark that whenever I tried to ask Mendeléef what was his (then) opinion on this subject he invariably evaded this topic, for until his death he held the view that elements are true "individuals" from (−) eternity to (+) eternity!

Conclusion.

I recommend the new International Commission to adopt the following nomenclature:—

(1) *Atomic Masses* only for the whole numbers of the isotopes B, as determined ***physically*** by Dr. Aston's method.

(2) *Atomic Weights.* This term justified by its historical and wide-spread use should be applied for the numbers as obtained by ***chemical methods*** and by the use of the ***balance***, no distinction being made between ***pure*** elements, mixtures of isotopes or single isotopes.

Accordingly I beg to propose to call the Sub-Committee of the "International Commission on Chemical Elements" a "Sub-Committee for *Atomic Weights.*"

Chemical Laboratory,
Bohemian University, Prague.
October 1, 1921.

VOLUMETRIC ESTIMATION OF MIXTURES OF PERMANGANATE, DICHROMATE, AND CHROMIC SALTS.

By NITYA GOPAL CHATTERJI, M.Sc.

(1) *Estimation of a Mixture of Permanganate and Dichromate.*

THE method is an extension of the well-known method of Volhard for the volumetric estimation of manganese. It depends upon the fact that a solution of permanganate can be easily and completely removed as insoluble hydrated manganese dioxide by the addition of a mixture of solutions of manganese sulphate and zinc sulphate. Instead of zinc sulphate, a soluble salt of magnesium, calcium, or strontium can be used. We have reasons to believe that the action of these salts is primarily to coagulate the colloidal manganese dioxide formed by the interaction of permanganate and manganese sulphate, though Volhard and others believe that the zinc sulphate or oxide forms an insoluble manganite.

Procedure.—The mixture of permanaganate and dichromate is first titrated against a standard solution of ferrous sulphate, the end point being easily marked by the appearance of a permanent dirty pink colour. From this the total iron equivalent of the mixture is obtained. Now 20 or 25 cc. of the original mixture is taken, and to it is added slowly a hot solution of manganese and zinc sulphates with constant shaking until the pinkish tinge of the permanganate is no longer visible. To ensure complete decomposition of the permanganate, a slight excess of the sulphate solution is added. Filter off the precipitate of hydrated manganese dioxide, wash thoroughly with hot water containing a little dilute sulphuric acid, and make up the filtrate and washings to a known volume. Find out the strength of the dichromate solution contained in the filtrate by direct titration with standard ferrous sulphate solution.

(2) *Estimation of Mixtures of (a) Dichromate and Chromic Salt, and (b) Permanganate and Chromic Salt.*

The estimation of these mixtures depends upon the fact that a solution of a chromic salt is completely oxidised to dichromate by heating an acidulated solution of it with hydrated manganese dioxide prepared in a special manner.

Preparation of the Hydrated Manganese Dioxide.—A solution of pure manganese sulphate is placed in a large porcelain dish and a few grms. of potassium or sodium nitrate are added to it and the mixture heated. Drop by drop a solution of potassium permanganate is added, and the mixture is vigorously stirred. The addition of the permanganate is continued till there is a very slight excess of it. The precipitate is filtered and washed free from electrolytes with hot water. The substance is then dried at 40-45° C., and kept in a stoppered bottle. It is of a dark-brown colour.

Procedure.—(*a*) *Permanganate and Chromic Salt.*—Take 20 or 25 cc. of the mixed solution, add to it about a grm. of the manganese dioxide and a few drops of dilute sulphuric acid, and boil for two or three minutes. Filter, wash, and make up the filtrate to a known volume together with the washings. Find out the strength of the filtrate by titrating a standard solution of ferrous sulphate. This gives the iron equivalent of the mixed solution. Take another quantity of 20 or 25 cc. of the mixed solution, heat and add slowly a mixture of manganese and zinc sulphates with constant shaking till the colour of the permanganate is no longer visible. Add a slight excess of the sulphate solutions, about half a grm. of hydrated manganese dioxide, and boil for a few minutes. Filter and wash, and make up the filtrate and washings to a known volume. (Usually the manganese dioxide precipitated by the decomposition of the permanganate is found to be sufficient for the oxidation of the chromic salt, but it is better to add an excess of the oxidising agent.) Find the strength of the filtrate by titrating against a standard ferrous sulphate solution. This gives the iron equivalent of the chromic salt solution, and the difference between the first and second titrations gives the strength of the permanganate solution.

(*b*) *Dichromate and Chromic Salt.*—The amount of the dichromate is first determined by titration against a standard ferrous sulphate solution. A known quantity of the mixed solution is then oxidised by hydrated manganese dioxide, filtered and washed, and the strength of the filtrate determined in the usual manner. This gives the total amount of the dichromate and chromic salt, and hence the difference between the second and the first titrations gives the amount of the chromic salt.

The method seems capable of being applied for the determination of chromium and manganese in steel, to investigate which experiments are being carried on.

Research Department,
Government Technological Institute,
Cawnpore (India).
September 14, 1921.

THE SOLUBILITY OF PHTHALIC ACID IN WATER AND SODIUM SULPHATE SOLUTIONS.

By L. McMASTER, E. BENDER and E. WEIL.

THE purpose in undertaking this work was to determine the solubility of phthalic acid in water and in sodium sulphate solutions of different concentrations at different temperatures, because the literature records but few facts concerning the solubility of phthalic acid. Vaubel (*J. prakt. Chem.*, 1895, (2), lii., 72; 1899, lix., 30) gives the solubility of phthalic acid in water at 14° as 0·54 grm. per 100 grm. of solution. Graebe (*Ann.*, 1887, ccxxxviii., 321) gives its solubility at 99° as 18 grm. per 100 grm. of solution. In the preparation of phthalic acid it is often set free by treating its sodium salt with sulphuric acid and it was for this reason that its solubility was determined in sodium sulphate solutions. These solutions were made up to be 10 and 15 per cent by weight.

The purity of the phthalic acid used was from 99·95 per cent, with 0·02 per cent ash, to 100 per cent. No attempt was made to purify the acid further. It was supplied by the Monsanto Chemical Works. Pure anhydrous sodium sulphate was used. All solutions were prepared with water from which the carbon dioxide had been removed.

Experimental.

The method followed was somewhat similar to that of Walton and Judd (*Jour. Amer. Chem. Soc.*, 1911, xxxiii., 1036). The acid was put into 175×55 mm. heavy-wall glass tubes with the water or sodium sulphate solutions, and agitated until equilibrium was attained. The tubes were immersed in a constant temperature water-bath, which was controlled by a mercury-column regu-

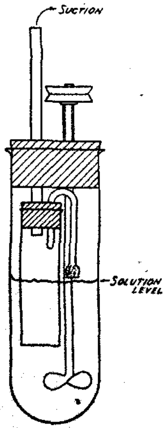


Fig. 1.

lator. At 25° a standardized thermometer reading from the −10° to +32° and graduated in 0·02° was used. For the higher temperatures a thermometer reading from −10° to +100° and graduated in 0·1° was used. The bath was kept constant to ±0·02°.

When equilibrium was reached the undissolved acid was allowed to settle and the saturated solution was drawn through an asbestos filter into a weighing tube (Fig. 1). Above 55° the solution was blown over into the weighing tube to prevent vaporisation under the reduced pressure. The delivery tube was steam-jacketed to prevent crystallisation of the acid in the tube (Fig. 2).

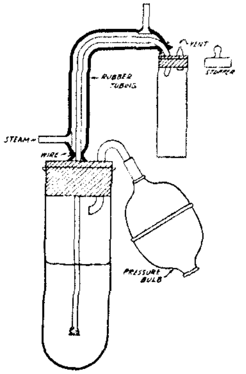


Fig. 2.

The weighing tubes containing the solutions were allowed ample time to come to room temperature before being weighed. The saturated solution was then carefully washed into beakers and titrated against standard sodium hydroxide solution, using phenolphthalein as an indicator.

The necessary time for the equilibrium was arrived at by taking samples every hour. A number of determinations showed that six hours at least was required for equilibrium to be established between the solid and its solutions. The results in each case recorded below are the average of several obtained by approaching the equilibrium both from undersaturation and from supersaturation. Considerable difficulty was experienced in getting the sodium sulphate solutions to yield concordant results.

It will be noticed that the solubility of the phthalic acid decreases with increased concentration of the sodium sulphate. More marked divergence of the solubility is noticed between the 10 per cent and the 15 per cent salt solutions than between the water and the 10 per cent solutions. There is also great increase in solubility of the acid with rise in temperature. These facts can readily be seen by referring to Fig. 3.

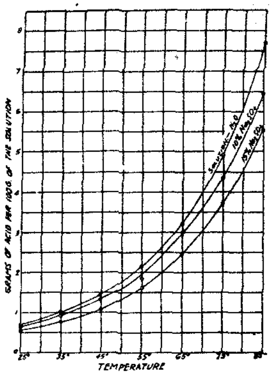


Fig. 3.

Grms. of Phthalic Acid per 100 grms. of the Saturated Solution.

Temp. °C	Water	10% Na_2SO_4	15% Na_2SO_4
25	0·7014	0·6440	0·5272
35	1·0125	0·9338	0·7575
45	1·446	1·341	1·080
55	2·168	1·858	1·639
65	3·246	3·018	2 455
75	4·926	4·373	3·748
85	7·687	6·461	5·533

—*Journal of the American Chemical Society*, vol. xliii., No 5, May, 1921.

NOTES.

"INFRA-RED SPECTRA OF ISOTOPES."—By F. W. LOOMIS.—*Separation of the Infra-red Absorption Doublets of HCl and HBr due to Isotopes; theory.*—If these bands are produced by the vibration of the nuclei along the line of centres of the molecules, the author shows that the frequencies should be approximately proportional to the square root of $(m_1+m_2)/m_1m_2$; hence the band lines due to HCl^{35} and HCl^{37} should differ by 1/1330, and those due to HBr^{79} and HBr^{81} should differ by 1/6478. In the case of the HCl band at 1·76μ, Imes found doublets whose components agree in separation and relative intensity with the theoretical results. In other cases the computed separations are less than the resolving power so far used. — Abstract from the *Astrophysical Journal, November*, 1920, lii., 248-56.

THE EXCITATION OF LIGHT BY CATHODE RAYS IN AIR.—By Gordon S. Fulcher.—*Light Excited by Cathode Rays in Air.*—A beam of cathode rays, after passing through a hole in the anode of the

discharge tube in which the rays were produced, was placed at the focus of the collimating lens of a spectrograph, and the *intensity of the nitrogen bands* excited was determined for various discharge potentials and for various distances apart of the electrodes. The results show that, unlike canal rays, cathode rays in passing through nitrogen excite less light per collision the greater their energy, at least *for the range of speeds corresponding to from* 1500 *to* 3500 *volts*. Since the rays used were not homogeneous, the exact law of variation cannot be determined from the data obtained, but the results indicate that the light per collision varies inversely as a power of the speed somewhat less than the second; and it is pointed out that if, as is quite possible, the light intensity per collision varies with the speed in the same way as the chance of ionisation per collision, then the light intensity per ionising collision is independent of the speed.—Abstract from the *Astrophysical Journal*, December, 1920, lii., 278-85.

BOOKS RECEIVED.

"The Popular Chemical Dictionary: A Compendious Encyclopædia." By C. T. Kinggett, F.I.C., F.C.S. Second Edition. Pp. viii+539. Illustrated. London: Ballure, Tindall & Cox. Price 21s. net.

"Atomic Theories." By F. H. Loring. Pp. vi.+218. London: Methuen & Co. Ltd.

"Confectioners' Raw Materials: Their Sources, Modes of Preparation, Chemical Composition, the Chief Impurities and Adulterations, their more important Uses, and other Points of Interest." By James Grant, J.P., M.Sc.Tech., F.I.C., F.C.S. Pp. 172. London: Edward Arnold & Co. Price 8s. 6d.

"Organic Analysis: Qualitative and Quantitative." By E. de Barry Barnett, B.Sc. (Lond.), F.I.C., and P. C. L. Thorne, M.A. (Cantab), A.I.C. Pp. xi.+168. Illustrated. London University Press. Price 7s. 6d.

New Patents.

This List is specially compiled for the *Chemical News* by Messrs. *Rayner & Co., Registered Patent Agents*, of 5, Chancery Lane, London, W.C.2., from whom all information relating to Patents, Trade Marks and Designs can be obtained gratuitously.

Latest Patent Applications.

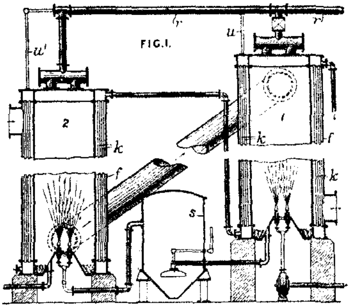
26571—Briggs, P. R.—Manufacture of sulphate of ammonia October 7.
26324—British Dye-stuffs Corporation, Ltd.—Manufacture of dye-stuffs of the triarylmethane series. October 5.
26555—Forwood, G. F.—Treatment of hydrocarbons. October 7.
26247—Imray, O. Y.—Manufacture of optically-active aromatic amino alcohols. October 4.
26214—Levin, I. H.—Electrolytic cells for generating oxygen and hydrogen. October 4.
26681—Wulfing, J. A.—Water-soluble compounds of diethyl-barbituric acid and its homologues, and manufacture of same. October 8.

Specifications published this Week.

146234—Kolshorn, E.—Process for the manufacture of salts of compounds of lactic acid with tannic or gallic acids.
169513—Pratt, W. B.—Sulphur terpene compounds.
147711—Verien Chemischer Fabriken—Manufacture of hydro-fluoric acid from natural fluorides.
169539—Dempster, Ltd., R. & J., Knight, H. S., and Siddall, F. J.—Combined generating and heating plant adapted to the manufacture of hydrogen.
169536—British Cellulose and Manufacturing Co. Ltd., Badder, W., and Nightingale, D. A.—Manufacture of alkyl amines.

Abstract Published this Week.

Distilling Ammoniacal Liquor.—Patent No. 167719.—Messrs. Holmes & Co. Ltd., of Whitehouse Ironworks, Huddersfield, and Wyld, W., of West View, The Avenue, Roundhay, Leeds, have patented an improved process of distilling ammoniacal liquor, a suitable apparatus for which is illustrated in the accompanying drawing. The heated liquor is sprayed in succession into two or



more evaporating chambers 1, 2, the pressure in the first chamber being utilized to effect the spraying into the second. The liquor may be passed through an intermediate chamber *s*, in which it is mixed with a reagent to liberate fixed ammonia. The chambers 1, 2, *are heated by flue gases circulating in jackets, f. The ammoniacal* liquor is preheated by passage through tubes, *k*. in the jackets. Connecting pipes *u*, u^1, serve to pass the gases generated during the heating of the liquor in the tubes, *k*, to the collecting main, *r*, which leads to a saturator for the formation of ammonium sulphate. If pure ammonia is to be separated, the first evaporating chamber is surmounted by a column up which the vapours pass, and down which a portion of cold ammoniacal liquor flows and removes ammonia from the vapours. The liquor falls through the perforated top of the spraying chamber. The liquor from the base of the chamber is passed through a vessel, *s*, and then in succession through spraying chambers from which ammonia gas is withdrawn.

Copper, Nickel, Sodium Salts.—Patent No. 168097.—Mr. E. E. Naef, of 16, Loughborough Road, West Bridgford, Nottingham, has patented a new process of treating finely divided copper-nickel matte. A mixture of copper and nickel sulphides is heated with powdered caustic soda or with a mixture of caustic soda and sodium carbonate, common salt, sodium sulphide, sodium sulphate, or lime, and with or without the addition of a small proportion of powdered coal. The operation may be performed in an open or closed vessel, or in a rarefied or inert atmosphere, or in hydrogen. Sulphides, hydrosulphides and *thiosulphates of sodium are formed* and metallic copper and nickel are precipitated. Lime, with or without the *addition of other salts, may be used instead of caustic soda*, the temperature required being higher than in the case of caustic soda. The molten salts may be poured off, or the whole mass may be treated with water to dissolve the salts. The mixture of metals, may be separated by a carbonyl process, or it may be treated with sulphuric acic for the formation of nickel sulphate, the undissolved copper being refined electrolytically or converted into oxide and thence into sulphate.

Messrs. Rayner & Co., will obtain printed copies of the published specifications and will forward on post free for the official price of 1/- each.

NEW COMPANIES.

The under-mentioned particulars of New Companies recently registered are taken from the Daily Register compiled by JORDAN & SONS, LIMITED, Company Registration Agents, Chancery Lane, W.C.2.

AMISOL, LIMITED.—(177209)—Registered October 11th, 1921. To carry on the business of Manufacturing Chemists, Druggists, Drysalters, etc. Nominal Capital: £2,000 in 2,000 Shares of £1 each. Directors: To be appointed by Subscribers. Qualification of Directors: £100. Remuneration of Directors: To be voted by Company in General Meeting. Subscribers: T. Thomas, 1, Woodthorpe Terrace, Huddersfield; S. Wilman, "Norfolk Villa," Dewsbury; W. Sowden, "Fernleigh," 48, High Street, Cleckheaton; T. C. Hammond, "Hopewell," Lightcliffe; E. V. Chambers, "The Manse," Lightcliffe.

BRUNT CHEMICAL CO. LIMITED.—(177274)—Registered October 14th, 1921. 21, Cannon Street, Manchester. To carry on the business of Chemists, Druggists, Drysalters, Oil and Colourmen. Nominal Capital: £1,000 in 1,000 Shares of £1 each. Directors: Harry Herbert Brunt, "Aysgarth," Ashton-on-Mersey, (Governing Director); Herbert Brunt, 56, Longton Grove, Sydenham, S.E. Qualification of Directors: £100. Remuneration of Directors: To be voted by Company. Governing Director: £500.

MEETINGS FOR THE WEEK.

Tuesday, November 1.

Mineralogical Society, at 5.30.—Anniversary Meeting. "On the determination of the optic axes of a crystal from extinction-angles" by Prof. H. Hilton. "An example of quartz twinned on the Sardinian law" by Dr. J. Drugman. "Biographical notices of mineralogists recently deceased; with an index of those previously published in the Mineralogical Magazine" by Dr. L. J. Spencer.

Wednesday, November 2.

Society of Public Analysts, 8. "An Improved Specific Gravity Apparatus" by C. Butler Savory, M.D., M.Ch. "The Testing of Foodstuffs for Vitamins" by J. C. Drummond, D.Sc., F.I.C. and A. F. Watson, D.Sc., A.I.C. "The Inks of Ancient and Modern Egypt" by A. Lucus, O.B.E., F.I.C.

Thursday, November 3.

Royal Society. "Spectra of Lead Isotopes" by Prof. T. R. Merton. "Experiments with Rotating Fluids" by G. I. Taylor. "The two-dimensional slow Motion of Viscous Fluids" by Prof. L. Bairstow, Miss B. M. Cave and Miss E. D. Lang. "The Production of Single Crystals of Aluminium and their Tensile Properties" by Prof. H. C. Carpenter and Constance Elan. "On the Transmission Colours of Sulphur Suspensions" by Prof. C. V. Raman and B. Ray. "The Law of Distribution of *Particles in Colloidal Solution*" by Prof. E. F. Burton and Miss E. Bishop.

NOTICES.

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PATENTS, TRADE MARKS. Handbook and advice free—B. T. KING, British and U. S. Regd. Patent Attorney, 146a, Queen Victoria St., London. 35 years reference.

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CHEMICAL REACTIONS ON SURFACES.*

By IRVING LANGMUIR.

(Concluded from p. 230)

If θ_1 is the fraction of the surface covered by this atomic hydrogen, then the chance that any given elementary space on the surface shall contain a hydrogen atom is θ_1. The hydrogen atoms have a very strong field of force, since they are unsaturated chemically (for the electrons are not arranged in duplets). These atoms, therefore, have a relatively low rate of evaporation from the surface. Two atoms in adjacent spaces on the surface, however, may react with one another to form a hydrogen molecule. This is chemically saturated, and has therefore a weak field of force, so that it evaporates rapidly from the surface. The rate of evaporation of molecular hydrogen is thus proportional to its rate of formation from the atomic hydrogen, and this, in turn, is proportional to θ_1^2 for the chance that *two* atoms shall lie in adjacent spaces is proportional to the square of the chance that an atom shall be in any given space. This statement of the problem lends itself readily to mathematical treatment, and the equations that were obtained for the dependence of the reaction velocity on the temperature and pressure are in full accord with experimental facts over a temperature range from 1500° K. to 3500° K. and pressures from 10 bars up to atmospheric pressure.

It is probable that the decomposition of ammonia, and also the formation of ammonia in contact with solid catalysts, depends upon similar interaction between adjacent adsorbed atoms. Reactions of this sort should be extremely sensitive to the actual distances between, and the arrangement of the atoms in the surface of the catalyst. If these atoms are a little too far apart, or if their electrons are not sufficiently mobile to permit of the electron rearrangement involved in surface reactions, the reaction will be much retarded. It is the opinion of the writer that these differences in the geometrical arrangement of the surface of the atoms is responsible for the "activation" of catalysts which is brought about by the action that takes place upon them. For example, if a plane surface of platinum be heated for the first time in a mixture of hydrogen and oxygen, the temperature has to be raised quite high before the reaction begins. When the reaction has occurred, however, even in gases at very low pressures, so that no appreciable heating effect takes place, the catalyst becomes modified and the reaction then proceeds, even at room temperature. In many cases, such effects are due to catalytic poisons, but there is good evidence that the effect is frequently caused by changes in the structure of the surface itself, brought about by the reaction. This is particularly noticeable in the catalytic oxidation of ammonia in contact with platinum wire. After the wire has been used, the surface becomes very rough, and gradually a disintegration of the wire occurs, because of the surface changes taking place. The catalytic activity of the wire is very low when first used, but becomes much greater after it has become activated by the reaction itself.

The changes that occur in the surface of the platinum under these conditions seem to be exactly similar to those that are caused by rapid fluctuation of temperature. When tantalum filaments, or certain improperly made tungsten filaments, are run in lamps on alternating current, the wire shows a tendency to "offset," but this effect is entirely absent if the wire is heated to the same temperature by continuous current. This offsetting consists of a slipping of the crystals of the metal along the boundary planes. In extreme cases it leads to a nearly complete disintegration of the structure of the metal. Experiments show that this effect is directly dependent upon the rapidity of temperature fluctuation. Anything that increases the rapidity of temperature fluctuation, such as the introduction of hydrogen into the bulb, increases the rate at which offsetting occurs, so that it is possible in a few minutes to produce as much offsetting as would otherwise occur during hundreds of hours. Under these extreme conditions, the rate of cooling of the filament is of the order of a million degrees per second.

If a Coolidge X-ray tube is operated exclusively with direct current, even during manufacture, the surface of the target retains its high polish, even after long use. A few minutes' running with alternating current roughens the surface of the target, and it is well known that the focal spot in the target assumes an appearance which is quite analogous to that of the platinum surface used as a catalyst for the oxidation of ammonia. It is highly probable that the cause is the same in both cases, namely, sudden fluctuations in temperature between adjacent atoms in the material.

In a surface of crystalline platinum, where the atoms are presumably arranged in a definite surface lattice, the distances between adsorbed atoms which occupy adjacent spaces is probably a nearly fixed quantity, and in general it is unlikely that this fortuitous spacing is the best adapted to the interaction between the adsorbed molecules. When the surface atoms have been pushed around and made to assume new positions, arranged more or less at random, the distances between adjacent adsorbed molecules vary over a wide range, and some of these distances will be exactly right for the reaction to occur at the highest possible speed. The surface thus becomes composite, and there is then a relatively small fraction of the surface at which the reaction occurs with extreme rapidity, while over the larger part of the surface it takes place at a very slow rate.

When a surface has become so roughened that it is porous, the effective surface area increases, and the number of favourable locations for the reaction to occur may become much greater.

There is good evidence, however, that the activation is not merely due to an increase in the surface, for a surface which becomes activated for one reaction may not become activated for another reaction. For example, a plane surface of platinum, by a single treatment in a hydrogen oxygen mixture at low pressure, can have its activity so much increased that the temperature at which the reaction begins is lowered from 150° C.

* A Paper read before the Faraday Society

to room temperature, but this increase in activity for the hydrogen oxygen reaction is not accompanied by any change in the reaction velocity observed in the reaction between the carbon monoxide and oxygen.

The experimental evidence seems to indicate that the reaction that occurs between oxygen and hydrogen on the platinum results from interaction between adjacent adsorbed atoms, while the reaction between carbon monoxide and oxygen takes place between oxygen atoms adsorbed on the surface and carbon monoxide molecules from the gas phase which strike them. This difference in mechanism probably accounts for the different sensitiveness to surface conditions. It would also suggest that the energy imparted to the individual platinum atoms as a result of the reaction may be much less in the carbon monoxide reaction than in the hydrogen reaction. If this is so, the monoxide reaction should produce little change in the surface, and thus should not activate the catalyst for the hydrogen reaction.

The experimental evidence with carbon monoxide and oxygen on platinum (described in detail in another paper presented at this meeting), proves that nearly, but not quite all of the reaction between these gases occurs during collision of carbon monoxide molecules with the oxygen covered surface. In reactions of this kind, which occur as the result of collisions, we may expect that in some cases the exposure of the "flanks" of an adsorbed film to attack by colliding molecules may render them much more susceptible to chemical action. For example, it is conceivable—although in this particular case there is no experimental evidence for it—that, if the whole surface of platinum were covered by oxygen atoms, incident carbon monoxide molecules should be unable to react, while if only a certain limited portion of the surface were covered with oxygen, the monoxide molecules striking the oxygen atoms close *to the place where they are attached to the* platinum, might be able to react. In this case the oxygen film would be removed progressively from its bounding edge inward. It seems quite possible that this kind of action may be involved in some of the passivity phenomena observed with iron in electrochemical action, and may be also effective in causing the *sudden* beginning of the dissociation of hydrogen by a tungsten filament after small traces of oxygen have been consumed by the filament.

If we consider catalytic surface reactions with more or less complicated organic molecules, we should naturally expect that the orientation of the molecules and steric hindrance effects should become more important as factors in the mechanism of the reaction. For example, when ethyl acetate is heated with different solid catalysts, it may give—

A. $CH_3CO_2H+C_2H_4$
B. $CH_3CH_2CH_3+CO_2$
C. $CH_3COCH_3+CO_2+C_2H_5OH+C_2H_4$.

In all these cases, the —COO— group is unquestionably directly attached to the surface, while the rest of the hydrocarbon chain is located above this group. It is probable that the —COO— group is attached to the surface by primary valences, so that the bonds between these atoms disappear when the substance is adsorbed. Depending upon the different manners in which interaction between atoms and evaporation may occur, the resulting products differ. Reaction A involves only a shift in the position of a hydrogen nucleus, to allow the products to evaporate separately. In reaction B it is only necessary for a few electrons to shift their positions. Reaction C involves interaction between two molecules which must be adsorbed in adjacent positions in definite geometrical relations to one another.

Reactions at Boundaries of Phases.—Faraday observed that a perfect crystal of sodium carbonat eor sodium sulphate ("Experimental Researches," Everyman's Library Edition, p. 109) refuses to effloresce until the surface is scratched or broken, and that the efflorescence then spreads from the injured place Similar phenomena have been observed with copper sulphate and other crystals. In all such cases it is necessary to assume that the reaction (dehydration) *takes place only at the boundary between two phases.* Careful analysis (Langmuir, *Jour. Amer. Chem. Soc.*, 1916, xxxviii., 2263-2267) shows that wherever we have to deal, according to the Phase Rule, with separate phases of constant composition, the reaction occurs only at the boundaries of phases. Thus in the dissociation of calcium carbonate by heat, the carbon dioxide is produced only at the boundary between the calcium carbonate and the calcium oxide phases.

Dr. H. S. Taylor recently described experiments on the preparation of copper and copper oxide catalysts (Rochester Meeting, Amer. Chem Soc., April, 1921) in which he found that there was a long "period of induction" in the reduction of heated cupric oxide by hydrogen. All the phenomena that he observed in connection with this reaction are in accord with the view that this is another case in which the reaction occurs only at the junction between phases. In conventional nomenclature we may say that we have here an example of autocatalysis, the metallic copper accelerating the reaction. It seems much more profitable, however, to analyse the phenomena in terms of the probable mechanism.

The oxygen atoms in copper oxide are thoroughly saturated chemically, which means in this case that they have taken up two electrons from the copper atoms and have thus completed their octets, and leave the copper in the form of ions. Thus there is no reason for expecting a strong tendency to react with hydrogen at moderate temperatures. In view of Taylor's experiments, we conclude that the oxygen ions in cupric oxide are in fact very inert towards molecular hydrogen. Let us assume that, owing to some local imperfection in the space lattice of the atoms of the copper oxide, an ion of copper has taken up electrons and has formed a neutral atom. It is to be expected that such an atom should behave towards hydrogen molecules like metallic copper or other metallic substances. We have already seen that hydrogen molecules are adsorbed by platinum and by tungsten (and therefore probably by other metals) in the form of atoms. This action is presumably caused by the attraction of the "free" electrons of the metal upon the hydrogen nuclei. The hydrogen adsorbed by the copper in atomic condition can then react with the oxygen ions merely by the shifting of the hydrogen nuclei from the copper atoms to the oxygen ions, the electrons being transferred to another copper

atom Each hydrogen molecule thus supplies two electrons and is capable of converting and adjacent copper ion into a neutral atom. By such a mechanism it is clear that the reaction could proceed only at the junction between the phases.

THE PREPARATION OF PURE PLATINUM.*

By EDWARD WICHERS.

THE Bureau of Standards has been working for some time on the preparation of the several platinum metals in a high degree of purity. In the course of the work on platinum in particular, some observations have been made which are of interest inasmuch as so-called pure platinum is in constant use in the collection of scientific data and in the control of industrial operations. Familiar applications are the use of the platinum resistance thermometer and the rare-metals thermocouple.

Since the chemical methods of detecting small quantities of impurities in platinum are not, in most cases, of proved reliability, it was decided to continue purification until the spark spectrum of the platinum should be as nearly as possible free from the lines of any foreign metal. It was found that repeated precipitation of ammonium chloroplatinate would yield metal of the desired purity. The platinum hereinafter described was obtained by four such precipitations, starting with material which contained significant amounts of palladium, rhodium, and iridium, as well as considerable iron, tin, and other base metals. These results are given because the impression has been more or less prevalent that pure or "thermo-element" platinum could not be prepared by this simple and economical method. The experience of Archibald (*Proc. Roy. Soc. Edinburgh*, 1909, xxix., 721), as well as others, in thus preparing platinum of any desired purity has not been sufficient to dispel the idea that some more complicated and tedious process is required.

Each precipitate of ammonium chloroplatinate was drained from the mother liquor in a Büchner funnel, then washed by stirring up the salt with a considerable volume of a 15 to 20 per cent solution of ammonium chloride, and again drained as before. This washing was always done twice, and sometimes three times. The washed precipitate was dried, ignited to platinum sponge in an electrically-heated muffle furnace, and redissolved by aqua regia. The solution was evaporated several times with hydrochloric acid in order to remove nitric acid, before the next precipitation. The amount of platinum left in the mother liquor from the precipitation was usually not in excess of 1 per cent of the platinum in the precipitate.

The final precipitate of ammonium chloroplatinate was ignited to sponge in a porcelain dish over a gas flame. The dish was covered with a silica plate and a stream of hydrogen run in to facilitate the decomposition, and incidentally to prevent the slight loss of platinum which accompanies the ignition of ammonium chloroplatinate in the air.

In addition to the spetrosopic tests, the thermo-electric method of comparison was used. (The e.m.f. developed at a hot junction between two dissimilar metals has long been made use of in the study of the platinum group. White (*Phys. Rev.*, 1906, xxiii., 449) employed the thermo-electric method to examine thermo-element wires for inhomogeneity and contamination during use. Burgess and Sale, and Burgess and Waltenberg (*Bur. Standards Sci. Papers* 254 and 280) applied the method to the study of the composition of platinum ware. Most alloys of platinum with other platinum metals or the base metals which are present as impurities give a positive e.m.f. against platinum itself. Thus an alloy of platinum with 1 per cent of rhodium gives about 2450 microvolts at 1200°, positive to platinum.) The least positive sample of Heraeus wire in the possession of the Bureau was used as a standard and will be designated in the subsequent paragraphs as "A."

The samples to be tested were prepared by melting the sponge on a piece of lime in the oxy-hydrogen flame. The buttons were cleaned with hydrochloric acid and rolled into a thin strip with a small pair of flat rolls. There was apparently no perceptible contamination with iron in this process, although, as a precautionary measure, the strips were usually digested with hydrochloric acid.

The first samples prepared in this manner, although spectruscopically free from any trace of other platinum metals, invariably gave a considerable positive e.m.f. against "A." It was noted, however, that the spectrograms of these metals always showed the presence of calcium, and sometimes of magnesium.

Subsequent samples were prepared in the same way, except that the precaution was taken to use an oxy-hydrogen flame in which oxygen was in considerable excess, as suggested by Mr. Fairchild of this Bureau. Strips of platinum were then obtained wibch showed a *negative* e.m.f. against "A," varying from 2 to 38 microvolts at about 1200°. Upon direct comparison of several of our samples, together with "A," in the spark spectrum, the samples were found to be identical in all respects except for the presence of calcium and a trace of magnesium. The variation in the intensity of the calcium lines was found to be roughly parallel to the variation in the e.m.f., the most negative sample showing only a very slight trace of calcium. This sample will be known as "K." A thermo-electric comparison was then made between "A" and three additional samples of Heraeus wire, as well as a sample of themo-element wire made by an American manufacturer. The last-named gave 10 microvolts, two of the Heraeus wires 40 microvolts, and the third 170 microvolts at 1200°, all positive to "A." The Heraeus samples were compared spectroscopically and again showed various amounts of calcium while the most positive one also showed the presence of rhodium. None of the specimens of platinum here mentioned had been used previously, and all were carefully cleaned to remove any superficial impurity before the spectroscopic examination.

Similar variations are shown by the several *samples of Heraeus wire employed in the thermo*-couples used in the researches of Day and Sosman (*Carnegie Inst. Pub.*, 1911, 157) on the gas

* Published by permission of the Director of the Bureau of Standards from the *Journal of the American Chemical Society*, June, 1921.

thermometer. The greatest difference is about 185 microvolts at 1500°. These wires were personally obtained by Dr. Day from W. C. Heraeus, and were believed to represent the purest platinm obtainable.

Through the courtesy of Dr. Day, a comparison was made by Dr. W. P. White, of the Geophysical Laboratory, between the least positive of these samples (hereinafter designated as "B") and sample "A." "B" registered 18 microvolts. Later a direct comparison was made by us between "B" and our sample "K," the latter giving 21 microvolts negative at 1200°. On spectroscopic examination, the H and K calcium lines were found to be visible in K, and present with two or three times as great intensity in B. The magnesium line of wave length 2852·13 A° was faintly visible in both spectrograms.

From the fact that no differences were found in the spectrograms other than those mentioned with respect to calcium and magnesium, it is believed that a negative e.m.f. as obtained indicates higher purity and is not caused by the presence of some contaminating substance whose combination with platinum is negative to platinum itself.

It was also observed that the samples which contained the least calcium were remarkably soft, did not wet the lime as they were fused, and showed no perceptible recalescence on cooling. Those samples which contained somewhat greater amounts of calcium were observed to wet the lime during fusion and showed a marked recalescence. A button which was properly melted but subjected to a momentary flash of a reducing flame immediately wetted the lime, showed recalescence on cooling, and gave an e.m.f. of 90 microvolts at 1200° positive to a duplicate sample, which was fused only in the oxidising flame. Strips of platinum containing appreciable amounts of calcium were found to show the characteristic calcium flame when brought to the melting point in an oxy-gas flame. Calcium was readily detected in "A" by this means.

The physical properties of the lime, and possibly its purity, seem to affect the purity of the platinum melted on it to a slight extent, but the pricipal factor is clearly the nature of the flame used. The data obtained seem to justify the conclusion that the calcium oxide undergues some reduction if insufficient oxygen is used in the flame, and that the platinum takes up calcium and not calcium oxide. This was substantiated by melting nearly 200 grms. of platinm in an Ajax-Northrup induction furnace, using a tall porcelain crucible lined with powdered calcium oxide tamped around a mandrel. Under these conditions there is no possible source of reduction of the lime unless it should be by the platinum itself. The ingot which was obtained gave 5 microvolts negative to a satifactory sample prepared from the same sponge by melting in the oxy-hydrogen flame.

A few experiments were conducted to determine the suitability of crucibles made from magnesium oxide with a small amount of magnesium fluoride as a binder. A sample of platinum was melted in such a crucible surrounded by a graphite shell to act as a conducting crucible in an Ajax-Northrup induction furnace. The platinum was held at a temperature considerably above the melting point for about 15 minutes. The resulting button was extremely hard and brittle, and analysis showed a magnesium content of 3·0 per cent. A piece of foil similarly melted but held at about 1800° for three or four minutes showed a gain in weight equivalent to 0·33 per cent magnesium, assuming loss of platinum by volatilisation in this period to be neglible. This button was hard but could be rolled cold, and the resulting strip gave about 3000 microvolts positive to standard platinum at 1200°. Heating for several hours in the air caused the platinum to be coated with a greyish film, which was removed by borax applied to the strips during the heating. The e.m.f. was now considerably lower, indicating that a portion of the magnesium had been lost. As it was thought that the contamination of the platinum with magnesium might be due to the reduction of the oxide by the graphite, another sample of platinum was melted in such a crucible, but with substitution of a tungsten shell for the graphite. The resulting platinum button was again very hard and could not be rolled, and evidently contained considerable magnesium. A sample melted in a magnesia crucible in which no magnesium fluoride was used was also very hard. Although the tungsten could have caused a reduction of the magnesia, it is probable that the real explanation lies in the dissociation of magnesium oxide, whcih Tiede and Birnbraüer (*Z. anorg. Chem.*, 1914, lxxxvii., 129) observed as taking place rapidly at 1900°. A button of platinum melted on a cupel moulded from powdered magnesium oxide without a binder, by means of the oxy-hydrogen flame, was very soft, and registered 14 microvolts negative at 1200° to the Bureau's standard Heraeus wire. Under these conditions the magnesia evidently does not reach the temperature required for dissociation.

A passing reference to the alloying of platinum and calcium is made by Moissan (*Bull. soc. chim.*, [3], 1902, xxvii., 665), who observed that platinum, heated to boiling in the presence of lime by means of the electric arc, contained 2·54 to 3·01 per cent calcium. Tarugi (*Gazz. chim. ital.*, 1899, xxix., 1, 512) states that he obtained a platinum alloy with calcium by means of the reaction between a platinum salt and calcium carbide. Hodgkinson, Waring, and Desborough (CHEMICAL NEWS, 1899, lxxx., 185) obtained an alloy of the approximate composition $PtMg_2$ by passing magnesium vapours over platinum foil. In this connection the observation made some years ago by H. C. P. Weber ("Report of Committee on Quality of Platinum Laboratory Utensils," *J. Ind. Eng. Chem.*, 1911, iii., 688), of this Bureau is recalled. He found that certain pieces of platinum ware were alkaline to litmus after strong ignition. In one case at least Hillebrand obtained a definite qualitative test for calcium from the surface of an ignited crucible, and the inference was made that the calcium originated in the lime crucibles used for melting platinum, or in the lime salts used for polishing the finished ware. It is to be noted that while the present work indicates the presence of calcium as metal in the platinum, it would also be quite possible for ingots of platinum to enclose mechanically particles of calcium oxide, which might appear in the finished ware. It is clear from this that under favourable conditions the amount of cal-

cium taken up by platinum may be very significant, the more so when it is considered that the calcium will be gradually brought to the surface and removed and the properties of the platinum will therefore not remain constant.

It has been mentioned that the purest samples of platinum thus far prepared still show the presence of calcium spectroscopically. The calcium content of this platinum is undoubtedly very small, the intensity of the H and K lines in Sample "K" indicating an amount which is probably not in excess of 0·0001 per cent. An attempt will be made not only to determine the amount of calcium as definitely as possible, but also to approach still more closely the goal of absolute purity. It is proposed to make a study of the suitability of other refractories, such as thoria and zirconia, for melting pure platinum, and also to determine the optimum conditions for melting platinum on lime, inasmuch as this substance commends itself so highly because of its cheapness and availability.

It is further planned to make use of the temperature coefficient of resistance as an index of the purity of the various samples. This would furnish an experimentally determined quantity peculiar to the material examined and independent of any arbitrary standard of comparison such as must be used in the thermo-electric method. Such determinations would be of great value in the subsequent standardisation of new material. This method has the added advantage that the values obtained are capable of variation in one direction only, so far as is known, while the e.m.f. of a given sample may be positive or negative to absolutely pure platinum, depending upon the nature of the impurity.

Acknowledgments are made to Mr. F. W. Smither, under whose supervision the chemical work on platinum is conducted, and to the other members of the Bureau staff who assisted in this work, in particular Dr. W. F. Meggers, Mr. C. O. Fairchild, and Mr. Louis Jordan.

TRAINING FOR FOREIGN EXPLORATION.*

By H. FOSTER BAIN,
Director United States Bureau of Mines.

Mining engineering occupies a borderland. In common with other branches of engineering it is an "art and science by which the mechanical properties of matter are made useful to man in structures and machines"—but with a difference. The civil engineer digs a hole to put something in it, a foundation perhaps. The mining engineer digs a hole to get something out of it, the ore. If he puts anything into the hole, timbers to support the excavation perhaps, he does it grudgingly, and always with a view to the utmost economy of material. He cannot, as can his fellow professional, build with an eye to the long future. He must always face the fact that his main object is to get things out of holes, and that when he has got out of a hole all that nature had put in it, neither the hole nor the plant used in the work has any further value. There is but a modicum of salvage upon which he may count. In many particulars his work shows analogies to that of a contractor, and the same logic that leads a contractor to low first-cost installations is good, within reason, for the mining engineer. He does his work and moves on, and there is probably no profession calling for equal skill and learning in which the members wander more. Always they are seeking or extracting or utilising materials forming part of the crust of the earth, and usually are doing it under conditions or with equipment that is at least suggestive of being temporary. The mining engineer must improvise, and he must be versatile. Of him it may be written as Kipling has of the marine:

> "For there isn't a job on the top o' the earth the beggar don't know nor do.
> You can leave 'im at night on a bald man's 'ead to paddle 'is own canoe:
> 'E's a sort of a blooming cosmopolouse—soldier and sailor too."

To the lore of the geologist he adds the skill of the engineer and the science of the metallurgist. Always and everywhere an eclectic he adapts means to the end. Clearly where there are such varied duties and opportunities room for specialisation exists, and this is, indeed, the fact.

Mining engineers, employing that term in the broad general sense in which it has common usage, are called upon for three sorts of work: (a) geological; (b) mining proper; and (c) metallurgical. No one man may be expected to be competent in all three, and each branch is really a profession within a profession, but a man who stays long and achieves success in mining engineering must know something of all three, and young men who leave the schools, regardless of the point of the triangle at which they begin, seem in practice liable to end at either of the other. Each of the three has applications outside mining or verges over into other fields. Thus the border line between metallurgy and chemical industry is shadowy, the ties between mining engineering proper and civil engineering are many and close, and geology is a broad science which touches many fields aside from those related to ores and minable minerals. It is, however, the light that geology throws on the genesis and especially the occurrence of ores and minerals that interests the miner, and it is in finding minerals and guiding development that it is of most direct benefit to him. This work is fundamental to mining. And it is the work of the exploration engineer. It may be of interest to inquire as to the probable future demand for his services and the training necessary to qualify him for service. Since mines are wasting assets, the very life of the mining industry is dependent upon the continual finding of new mines, new ore bodies, and new reserves. When this stops, mining will stop, though the death may be a lingering one. Whatever may be true as to a particular type of mining, or mining in a particular locality, it must further be clear that so long as man persists on this earth he will have use and need for some portions of its crust, and that, therefore, mining in some form will continue. Each individual mine, be it ever so long lived, is eventually worked out and becomes worthless, and other mines must be found to take its place. The emphasis changes and minerals or metals

* Forty-eighth Annual Commencement Address, delivered on April 29, 1921, and reprinted from the Bulletin of the School of Mines and Metallurgy, University of Missouri, June, 1921, No. 3, vol. xiii.

eagerly sought by one people or one generation are less important to those who come later, sometimes because their wants are supplied from a different source. In the early settlement of the Mississippi Valley, local salt supplies were so important that salt lands were generally set aside as being of particular value. Now these local supplies are of so little importance that they are generally not worked. Nevertheless the salt industry is many-fold larger and more important than was contemplated by our grandfathers. The human need for salt is as great as ever, and with increasing population more salt, and hence more salt mines have been needed.

As there comes to be more people in the world there will be more need of mineral products, and disregarding the substitution of one for another, the minimum rate of increase in output for the minerals as a whole may be safely taken as that of increase of population.

There is an additional factor that lends assurance to the future of mining. As civilisation spreads and industrialisation becomes increasingly intensive, the per capita consumption of minerals increases. Man comes more and more to depend upon energy taken from the earth to supplement his own labour. The brilliant civilisation of the Greeks was based upon slave labour. It is worth remembering that in the golden age, which the classicists so love to recall, the mines of Larium, worked by slaves, were so productive that each citizen of Athens received a dividend in place of an annual tax notice. Naturally they had time to sit around in the sunshine and talk philosophy. The people of our times will not tolerate slavery. We have found a better way in that we harness to our use the energy of falling water and of fuels and so are each served by invisible, non-consuming genie of the earth. The peoples who make the most use of earth materials and forces are the peoples who work the shortest number of hours, produce the most goods, and have the most to divide among themselves. There are great differences between the peoples of various countries and centuries in this particular. Probably the civilized man, on the average, eats little if any more food than his ancestors did, but he does burn more coal and uses more metals. Even among the various peoples of the present there are differences. The Chinese use about one-twentieth of a ton of coal per capita per annum. Americans use approximately six tons, and other peoples use various amounts between. Generally speaking, the world is learning to use more and more coal and so to substitute the mechanical energy of heat for human labour. The pre-war per capita consumption of copper in the United States was 6 to 7lb., and for France about ½lb. In Russia it is much less, but nothing can be more certain that that through a term of years the peoples of other countries are going to approximate more closely to American standards of consumption. The United States is by no means the only country where modern plumbing is appreciated, and as the cult of the bath-tub spreads around the world the consumption of the metals will grow. This demand can only be supplied by re-use of old metal or by making addition to the world's stock. Mineral wealth, fortunately, is not necessarily consumed in use. There is wastage, but there is also salvage, and large amounts of old metal are continually returning to use, so much so that important metallurgical processes, such as making open-hearth steel and cement copper are based upon supplies of scrap metal.

The existing stocks of the various metals represent accumulations of all the centuries that have gone before, though very much the larger part has been won within the last hundred years. There have been times in the past when but little was added to the stock, and there have been peoples who merely captured in war and used the metals mined by others. This was true of the Tartar dynasties in China. The peoples who ceased to mine ceased to progress in civilisation, and the great civilisations of the past were those in which the people laid under tribute more and more of the earth.

As yet no peoples are known who have accumulated a sufficient stock of metals to supply themselves by remelting, and at the same time to make progress in civilisation. Having regard to the many activities that lead to wastage it seems improbable that any active people will reach the stage where they will not require periodic additions to their stock of metals. In the opinion of economists, also, no active people have yet reached a point of saturation as regards even steel, the most common of our metallic alloys. It seems, therefore, safe to assume that demand for minerals will continue to increase.

Two methods of meeting this increasing demand are known. By improvements in technology and financing it will be possible to lower the limit of metal content which separates ore from waste and so increase the reserves in known deposits or make into ore deposits what are now mere mineral segregations. This is a fruitful field and calls for application of the highest type of skill and genius in our profession. It is one in which remarkable results have been achieved. Working 1 per cent copper ores means handling 2000lb. of material to recover less than 20lb. of copper, for even the best practice involves losses. It is only possible to do this by application of excellent technology and remarkable powers of organisation and financing. In producing helium from natural gas a raw material containing less than 1 per cent is used, and the technology involves incursions into low temperatures and high pressures not previously applied on any large scale outside physical laboratories.

A second way to meet the future demand for mineral products is to discover new deposits either of types made profitable by the improvements of process and business organisation just mentioned, of types long known, or of new types. Fortunately there are opportunities of finding all three, and in all this work exploration enters. The search for "porphyry coppers" has been a wide one. Beginning in the United States, it has long since spread into foreign fields. It has led men into many of the odd corners of the earth, and there are regions yet to be explored. In conducting this work, knowledge of the widest character is desirable. When Mr. C. G. Gunther began his search in Mediterranean countries, which has resulted in the development of an American mine of promise on the Island of Cypress, the first step was a reading of the classics. The Romans and earlier rulers of the region had sources of copper

which, while small as judged by present American standards, might, it was thought, well point the way to a source for modern production. It will be recalled that the Utah, Chino, Ray, Nevada Consolidated, and other of our modern enterprises built on older small-scale undertakings. Mr. Seeley Mudd, the eminent mining engineer, who studied in a Missouri school and began his professional career in a Missouri copper mine, had the vision of applying in the Mediterranean region the knowledge which had grown out of American experience. He and his associates found in Mr. Gunther an excellent, enthusiastic agent. The work began, as I have intimated, with a careful review of the classics, and was followed by field studies first in North Africa and later in Asia Minor, where old mines offering promise of profit under modern methods were found. I cite this instance to enforce the observation that no knowledge comes amiss to an exploring engineer. I hope it will not be construed into an argument for making Greek and Latin required courses in mining schools, but it does show that wide learning is of real value to a mining man who proposes to do more than conduct a local and minor operation. As for Greek and Latin, mining men as well as others who can without undue sacrifice of time become acquainted with them will gain by doing so. It is well, though, to preserve a sense of proportion, and mere knowledge of foreign languages, ancient or modern, hardly qualifies one to assume responsibility as operator or advisor in mining. Indeed, a surprising amount of work can be done through interpreters, since to a good geologist the rocks speak direct, and a competent miner or metallurgist can piece together the story of old works and furnaces from scattered remains, drawing deductions as surely as does the vertebrate palæontologist from a few bones. Get all the knowledge of modern languages that circumstances permit. Some have a facility in this which carries them far, but remember that it is but a means to an end. In the course of a recent professional trip lasting some twenty months, business took me into countries and regions where eleven distinct languages or dialects were used, so distinct that for each interpreters were necessary. If I had stopped to learn each language before transacting business, I would never have found time to do the work for which I was sent. Such experiences are not unusual in these modern days of wide travel. It is helpful, but not necessary, to know modern languages. Even when no interpreter is available, a few simple words will carry you surprisingly far. It is not only that they are useful in themselves, but they help to establish friendly relations. People generally take it as an effort to good understanding that you have tried to become qualified to talk to them in their own tongue, and words in any language carry an accumulation of associations which is left behind in translating. You must, however, depend largely on yourself. Use your eyes and your feet. Get out into the field and observe. Leave, if you must, puzzling questions as to labour supply, laws and regulations, until you can get a competent interpreter, but for the facts as to character and extent of the deposit you wish to see depend on your own powers and energy.

I am speaking now of language study as a means. Language and the whole group of so-called cultural studies have another use, one not to be overlooked. If you purpose to be an exploration engineer, you will spend much time away from home, often under uncongenial surroundings. I once asked a young man returning from an outpost in West Africa what he considered most important for one to have before going into such work. I was a bit surprised when he answered, "a college education." Experience had taught him that a well-stored mind is the best companion, not only in solitude, but of a man surrounded by primitive and brutalising conditions to which he does not wish to succumb. It has been my experience to note young men of good antecedents who have dissipated and become mere brutes when left alone among savage or nearly savage people for lack of mental reserves. Mental balance and mental resources are of peculiar value as stabilisers under such conditions.

Search for "porphyry coppers" and similar deposits will almost certainly carry you into regions of ancient mining. It is well to be on your guard neither to underestimate or overestimate the older civilisations. The ancient miners did many things well. They are apt to have exhausted the bonanzas down to the water level, and high-grade ore in old workings is rare. Their costs were low since the mines were operated mainly by slave labour. It does not follow that because others worked a mine for centuries, or even because it yielded considerable aggregate of metal, it can profitably be exploited under modern conditions. With primitive tools the ancients accomplished wonders. There is, however, one assumption that it is usually safe to make—they did not work far below permanent underground water-level, since no amount of human labour quite accomplishes the work of modern pumps.

Just as we must remember that price relations of labour and metal were in ancient times very different from those of to-day, so we should bear in mind that in the past people were satisfied with amounts of metal that would be considered insignificant now. Mr. E. C. Eckel has pointed out that at the time of the discovery of America, the total amount of gold accumulated in Europe in all forms was worth less than $100,000,000, and that up to the American Revolution the iron made annually in this country was but 15,000 to 25,000 tons. Even at that it was equal to the output of England. Many deposits which would satisfy such demands are of no importance whatever under modern conditions of business and technology. Whole groups, therefore, of ancient workings may be passed in review quickly once you are satisfied as to their type and average extent.

Finding deposits suitable for large mining enterprises is, however, not the whole of the work of an exploring engineer. He may be employed to look up sources of some mineral which does not occur in large bodies, such as tungsten or vanadium. In such cases little bodies must be regarded as jealously as are large ones of cheaper metals. A due sense of proportion is of high value to him, and an intimate knowledge of the mode of occurrence of the mineral he is seeking to find is a first essential. Placer gold has a

natural habitat, and there are characteristic differences in types of deposits which may be correlated with the character of the country rocks, the extent of their metamorphism, the presence or absence of intrusives, the character of the latter, the physiographic history of the region and similar geological features. Much is known now of metallogenic provinces, and something of paleogeography. All this and more is useful to one engaged in finding ore.

In estimating the value of professional knowledge necessary for success as an exploring *mining engineer, I would, therefore, place a good* working knowledge of geology first. This should extend not only to the technic, but to the sources of information and to current knowledge of the geology of the region to be explored. A metallurgist or a mining engineer engaged in operation of properties does not need so comprehensive an understanding of geology. It is sufficient if he knows the general scope of the science and the particular ways it may be applied to problems he must face. It is by no means necessary that he should be versed in its technic, since there will always be within reach men skilled in the art who may be called to his assistance. What he should know is when a geologist can be helpful and how to use him in his work. It would be better for such men to concentrate their time and energy upon acquiring a complete mastery of their own work rather than an amateur and probably misleading knowledge of geology.

In the case of the exploring engineer the case is different. His prime function is to find ores, and to do this he must know ore bodies and the laws *which govern their occurrence. These laws* are imperfectly understood,; much regarding them remains to be learned, and to resolve these doubts calls for the most complete knowledge obtainable concerning the principles of geology, the history of the earth, and the technic of making geological studies. It is therefore important that the exploring engineer should be first of all a well-trained geologist, one capable of observing, recording, weighing, and judging the numerous facts of which account must be taken in making his determinations.

Much observation has convinced me, though as to this there are differences of opinion, that it is better if he learn his geology first as a scientific study. *There is a high value in the detached* point of view of the man who loves science for its own sake and counts truth as most important. Men so trained have usually more vision. They have a wider knowledge of the literature of the subject and of the work of others. They are less eager to accumulate only the facts of immediate importance and so have more facts and more theory upon which to fall back when in difficulty. They do their work better because they look over the whole problem first. Not infrequently they make large savings by eliminating unprofitable work through preliminary study of literature. For all these reasons I would recommend the man who purposes to devote his time to exploration to study geology first and to study it as though he expected to be a professional geologist.

This, however, is not alone enough. It requires but little knowledge of the field to recognise that many serious mistakes have been made through relying on the advice of geologists. For this particular work of finding ore is needed more than the usual equipment of a good geologist The latter is rarely versed in economics, and this is almost equally essential. Too many geologists have no adequate understanding of the relative importance of things from the miner's point of view. Not being trained in assuming financial responsibility for mistakes, they are cheerfully optimistic when to be unduly so invites failure. Their first tendency is to general advice, and all too promptly they will sketch out plans for development that call for millions when perhaps thousands alone are available. The geologist, therefore, needs further training before he is properly prepared to advise regarding mining development. As a geologist he is what one may call semi-finished material, though, I would have you understand, most excellent material for further manufacture.

When the prospective exploring engineer has completed his scientific studies he needs help and criticism from his fellows, the mining engineer and the metallurgist. It is not necessary that he should become equally learned in their branches of the profession, but it is essential that he have a clear conception of the scope, character, and limitations of their work. It is his business to find the ore which the mining engineer shall mine and the metallurgist treat. Clearly no one will be profited by his finding and mapping metalliferous segregations which cannot be mined or are not amenable to treatment. It may be highly interesting and of great scientific import to map such bodies of mineral, but that is the function among others of the geologists of official surveys. *The exploration engineer must work to find something out of which a profit may be made or he has* not found ore. Clearly he must know, at least in general terms, the limits of cost which separate ore from rock, and he must have some well-defined ideas of the technical difficulties to be overcome in mining each particular deposit, and of the methods likely to be applied. It is not necessary that he should be able to make the application. That calls for skill of another character, but he must know, and know surely, that some one of several methods, perhaps, may be applied, and must be able to approximate the cost. It is useless to find and drill placer ground where the boulders are too large and numerous, *or the bottom too hard or pinnacled to permit* dredging, while the supply of water, of storage space, or the grade prevents hydraulicking or sluicing. There are dry placers, it is true, but if the exploration engineer finds conditions so unfavourable he would do well to defer drilling until after taking expert advice as to methods and costs of dry washing. It is also useless to spend money on a careful examination of a placer property unless there is reason to anticipate that the gravel will yield as much or more than the cost of working elsewhere under similar conditions. To determine this, one must know what constitutes similar conditions and what usual and unusual costs are. It is no part of the ordinary training of the geologist to accumulate such data, and if he is to succeed in exploration he must draw on the experience of the engineer for it, either by serving an apprenticeship under him, or having always a competent engineer as an associate. The latter is not always feasible, and

it is greatly to the benefit of his future if the geologist will serve for a time as helper to a good engineer in operating or examination work. It will help him to get into the habit of quantitative thinking, and he will learn much of the law of averages. For one thing, engineering methods of sampling are on a much sounder basis than are those of the geologist. It is one of the minor tragedies of scientific work that so much high thinking is done over non-representative samples. Geologists generally have the same naive confidence as has the prospector and promoter in their ability to take a "grab" sample which will be representative, and this is a common source of error and disappointment.

Having said so much in disparagement of the profession which I have long loved, let me add that in the study of placers there is no knowledge that entirely compensates for lack of clear conceptions of geologic history and skill in geologic interpretation. Placers are the products of rivers or beach action. Their accumulation is an incident in river, lake, or marine history, and may be closely correlated with the physiographic history of a region. There are definite places at which they may be expected to occur, and others at which it is useless to seek them. Frequently they relate back to ancient rivers and to physiographic stages in the past whose marks, obscured by later changes, may be picked up only by the skilled eye, and of which the evidence may be correlated only by an active, well-trained brain. To indicate the need of supplementary training and experience is not to discredit what is sound and useful in that already given to geologists. While I have drawn my illustration from the field of placer mining, a similar argument may be made in the case of lode mining, where structure, secondary enrichment, and other phases of geology are equally important, but where also it is necessary to know in outline of mining methods, especially of the critical limits, both technical and financial, of their application. The situation is the same in exploration for gas and oil except that petroleum technology, being newer, is not as yet well formulated, and the financial limits are more elastic. The rewards of success in oil and gas production are so much larger in proportion to the immediate investment, and the returns are so much more prompt, that it is not possible to estimate probable costs as closely as in other forms of mining.

Consideration of costs leads one into the larger field of economics, a popular branch of learning just at present. Aside, however, from this new general interest in what was once called "the dismal science," and belief in its applicability to present-day problems, there are permanent reasons for the exploring engineer acquiring more than a slight acquaintance with economics.

(To be continued).

DICTIONARY OF APPLIED PHYSICS.

A "Dictionary of Applied Physics," an important work which Messrs. Macmillan have arranged to publish under the Editorship of Sir Richard Glazebrook, is now in an advanced stage of preparation.

The work, which is elaborately illustrated, will appear in five large octavo volumes, containing some 600 to 700 pages each, dealing respectively with:—

I. Mechanics—Engineering and Heat. II. Electricity. III. Metrology, Meteorology and Measuring Appliances. IV. Metallurgy and Aeronautics. V. Optics, Sound and Radiology.

The Editor has been fortunate in securing the *assistance of a distinguished body of Contributors*, and it is hoped that Vol. I. will be published in the early part of 1922. It will contain articles on Thermodynamics, the Theory of the Steam Engine, the Liquefaction of Gases and Refrigeration, by Sir Alfred Ewing. Sir Charles Parsons and Professor Stoney, with the assistance of their respective staffs, have written on the Steam Turbine; Sir Dugald Clerk and Mr. Burls on the Internal Combustion Engine; Professor Dalby on the Balancing of Engines; and Dr. E. H. Griffiths on the Mechanical Equivalent. The Editor is indebted to Dr. Horace Lamb for several articles on mathematical questions connected with the subject of the volume. Dr. Stanton has contributed an article on Friction, Mr. W. B. Hardy writes on Lubrication, and Mr. G. S. Baker on Ship Resistance. Mr. Jakeman, Mr. Batson, Mr. Hyde, and other members of the staff of the National Physical Laboratory have written on Manometers, the Determination of the Elastic Constants of Materials, Dynamometers and similar subjects. Mr. Southwell writes on the Theory of Elasticity, and Mr. Landon on the application of that theory to Structures. Professor Fulton treats of Hydraulics, and Professor Bulleid of the Kinematics of Machinery.

In the Heat Section, Messrs. Day and Sesman have discussed the Experimental Realisation of the Absolute Scale of Temperature; and Dr. Coblentz, of the U.S. Bureau of Standards, has contributed an important article on the Experimental Verification of the Laws of Radiation. Some account of Radiation Theory, with a short Article on the Quantum, is due to Mr. Charles Darwin; while Mr. Whetham has written on the Phase Rule. Articles on Calorimetry in its various branches and on Pyrometry have been contributed by Mr. Ezer Griffiths; Professor Porter has written on Thermal Expansion; Mr. Schofield on the Conduction and Convection of Heat; and Mr. Higgins on Thermometry, Viscometry and Flash Point Determination.

From the above particulars it will be seen that success has attended the Editor's efforts to secure, in each important subject, an Article from a recognised authority, and this same plan has been followed with equal success in the other volumes, which will appear at short intervals after the first.

PROCEEDINGS OF SOCIETIES.

SOCIETY OF GLASS TECHNOLOGY.

THE opening meeting of the Session 1921-22 was held in the Applied Science Department, The University, Sheffield, on Wednesday, October 19, 1921, the President, Dr. M. W. Travers, F.R.S.,

in the Chair. The following papers were read and discussed :—

"The Comparative Compositions of Pot Clays from the Stourbridge District during the last 50 years." By G. V. Evers.

"The Properties of Lime-Magnesia (Dolomite-Lime) Glasses and their Commercial Application." By Violet Dimbleby, B.Sc., S. English, M.Sc. F. W. Hodkin, B.Sc., and Prof. W. E. S. Turner.

NOTES.

British Developments in Nitrogen Fixation. —The synthetic ammonia factory at Billingham, designed to manufacture about 60,000 tons of ammonium nitrate annually for war purposes, was commenced by the Ministry of Munitions early in 1918, but at the time of the Armistice was only very little advanced. It has since been taken over from the Government by Messrs. Brunner, Mond, & Co. Ltd., and is being re-designed to manufacture peace products, chiefly fertilisers. The subsidiary company they have promoted, Synthetic Ammonia & Nitrates, Ltd., will have a capital of £5,000,000, is at present concentrating upon designs for an initial plant to produce 25 tons of ammonia per day, or about 6,000 to 7,000 tons of nitrogen annually. Their works are, however, being laid out so that this small nucleus installation may be quickly enlarged to 100 tons per day, and afterwards to a maximum capacity of 300 tons per day, or about 80,000 tons of nitrogen annually. The original Government site of 260 acres is being increased to about 1000 acres in all, and two ship berths on the River Tees have been acquired. This increased accommodation has been found necessary in order to give ample room for the development of the whole scheme, which includes the manufacture of a number of by-products. There is also to be an oxidation plant of a capacity of 10,000 to 12,000 tons of nitric acid annually. A British company, Cumberland Coal Power & Chemicals, Ltd., has also been formed to erect works in England to operate the Claude process for the manufacture of synthetic ammonia. Information to hand states that a full-size commercial ammonia unit, working at 1000 atmospheres, is now running satisfactorily in France, producing at the rate of 5 tons of ammonia per day. The British Cyanides Company are continuing at Birmingham their large-scale experiments on fixation of nitrogen by the barium process, employing fuel-heated furnaces. Though these experiments have been partially successful, final conclusions as to the ultimate possibilities of the process have not yet been reached. The works works erected at Dagenham by the Nitrogen Products Company to manufacture ammonium nitrate during the war period from cyanamide by the Ostwald process are now closed.—From the "Report of the Nitrogen Products Committee, Ministry of Munitions."

The Vacuum Hot-Spark Spectrum of Zinc in the Extreme Ultra-Violet Region.—By R. A. Sawyer.—*Hot-Spark Vacuum Spectrograph for Extreme Ultra-Violet.*—After reviewing briefly the work of Schumann and Lyman, the author describes the apparatus by which spectra extending to less than 300 A were obtained. As source of light, a condensed spark was used which, it has been found, can be passed between electrodes a millimetre or less apart if sufficiently high potentials are applied, even in extreme vacuum. This source and a specially ruled, short focus, concave grating and the slit and the plate-holder, each provided with the necessary adjustments, were mounted inside a brass tube, a meter long by 15 cm. in diameter, which was kept evacuated by a diffusion pump. On account of the gas given off by the electrodes, a series of sparks lasting 5 seconds could be allowed only every 5 minutes or so, but 20 to 30 minutes' total exposure was sufficient as a rule. After precautions were taken to minimize the corrosion of the grating by active gases and also fogging due to stray light and gaseous discharge, highly satisfactory results were obtained. *Ultra-Violet Spectrum of Zinc, 2200 to 316 A.*—The wave-lengths of about 100 new lines probably due to zinc, 80 of which are below 1400 A, are given in Table I., accurate to about 0·5 A. See Plate X for spectrogram.—Abstract from the *Astrophysical Journal*, December, 1920, lii., 286-300.

The Chemical Industry in Hungary.—The report upon the Hungarian chemical industry, read at a meeting of the National Society of Hungarian Chemical Products' Manufacturers, states that of the 245 works formerly in Hungary, there are now only 175, but there are hopes that before long new productive branches will be found. Those requiring large quantities of raw materials have little chance of great development for the moment, but manufacture of demi-products is promising. In spite of almost insurmountable obstacles, the Hungarian works during the last few months have not only met home demands, but also produced material for exportation, valued at several hundred of millions of francs, and everything indicates that Hungary will play a prominent part in the south-east of Europe, as soon as the restrictions now existing are abolished. The entire chemical industry is reviving, although Hungary has lost her salt works and those for manufacturing explosives, paper, and ethers. On the contrary, the manufacture of pharmaceutic and organic products is very flourishing. In the event of a good harvest, the alcohol, bone, fertiliser, starch, oil, and margarine industries will revive. Manufacture of soap, candles, colours, varnish, artificial silk and rubber is satisfactory.—*Industrie Chimique*, September, 1921.

Mr. Edmund White, B.Sc., F.I.C., ex-President of the Pharmaceutical Society of Great Britain, delivered the inaugural address when the Welsh College of Pharmacy was opened at Cardiff on Wednesday, and the medals and prizes for last year's work were presented to the successful students. Mr. White said that he had inspected the new College, and was very pleased with what he had seen. Cardiff was certainly among the first technical colleges to carry out the pharmaceutical training of students, and their school was one of the best. Principal Coles, reporting on the work of the department in the last session, said 15 students passed the Pharmaceutical Society's examinations and were now fully qualified chemists; nine of the previous year's students

had also passed. For the present session they had 55 full-time students, including 21 ex-service men, as compared with 22 last year. This showed that the school was becoming better known, and, as far as he knew, it was one of the biggest departments of its kind in the country. Out of the 15 students who passed the full test last session three were ladies.

ZINC CONCENTRATES.—The Board of Trade announce that they have instructed their agents in Australia to ship a supply of Broken Hill zinc concentrates to this country, and will be prepared if desired to maintain supplies to meet the immediate requirements of smelters in the United Kingdom. In order to enable smelters to re-start their works and provide employment, the Board will be prepared to consider offers for these concentrates delivered at works. Offers for future deliveries over a period will also receive consideration. The British Metal Corporation, Ltd., of 3, Abchurch Yard, London, E.C.4, have been appointed the agents of the Board of Trade for all business relating to concentrates for disposal in the United Kingdom, and all enquiries as to prices, terms, &c., should be addressed to the Corporation.

THE Sixth Annual Report on the work of the prescription pricing department of the Cardiff Insurance Committee, which prices chemists' prescriptions for the insurance committees in Wales and Monmouthshire, and for the Welsh National Memorial Association and the Pembrokeshire County Council, shows that the number priced in 1920 was 1,670,184, representing an increase of 31,562 on the previous year. The average number of prescriptions per insured person was approximately the same as for the year 1916, but the average prescription cost per person increased from 1s. 6·37d. in 1916 to 2s. 8·53d. in 1920. Increased ingredients cost and higher dispensing fees are responsible for the average cost per prescription being 4½d. more. The net expenditure of the pricing department for the year was £2,243.

PLATINUM metals may be detected by the "glow reaction" of Curtman and Rothberg as used by Logan ("Platinum and Allied Metals in California: Cal. State Min. Bur., *Bulletin* 85, 1919, p. 102). The test depends on the catalytic effect of finely divided platinum metal in the oxidation of illuminating gas. The material to be examined is dissolved in aqua regia and the test applied without any previous separation of elements. The test is more sensitive if the solution is not too acid. A very thin piece of asbestos paper, held by one end with tongs, is alternately dipped into the solution to be tested and heated until about 0·2 cubic cm. has been absorbed. The asbestos is then heated to redness, cooled until the redness is no longer visible, and then thrust at once, while still hot, into a stream of mixed gas and air from a Bunsen burner which is regulated to deliver the mixture at a rather low pressure. If platinum is present the asbestos glows for some time. When destroyed the property of glowing can be restored by heating to redness again. The test is made more intense by using warmed gas and is said to be sensitive to 0·002 mgrm. of platinum, 0·005 mgrm. of iridium, 0·0009 mgrm. of rhodium, and 0·0005 mgrm. of palladium, but does not reveal the presence of osmium or ruthenium.

VARIATIONS OF THE CATALYTIC POWER IN ELECTROPLATINOSOLS.—In a previous communication, M. A. de Gregorio Rocasolano noted some observations regarding the ageing of colloids, in a study made within an interval of some days, upon the variations of their catalytic power. He continued this study, directing his work to the processes of evolution continually undergone by colloidal systems, verifying the fact in some cases that the colloids, regarded as catalysers, undergo, even in very short periods of time, intense variations in their catalytic power. In one experiment with electroplatinosols, decomposing hydrogen peroxide during 30 consecutive hours, a reaction was produced with the same electroplatinosol of 0·0016 per cent divided into two parts, one without stabilisation and the other by adding 0·3 cubic cm. of aqueous gelatin solution at the rate of 3 per cent of colloid. All the reactions studied were obtained in similar conditions. These experiments demonstrated that not only does the catalytic power of electroplatinosols vary in each case, even within very small periods of time, but that these variations are much more intense in non-stabilised colloids than in the same systems stabilised. These variations are ascribed to the incessant differences in composition (concentration in oxygen) of the dispersed particles with the conclusion that the stabiliser acts by checking the processes of constant transformation in the colloids.—*Comptes Rendus*, July 4, 1921.

ARTIFICIAL RESINS.—The various sources of artificial resins are discussed by Mr. A. Tschirch in *Seife*, Nos. 28-29, 1921. Aldehyde resins are obtained by polymerisation of acetic aldehyde under the influence of alkalies. Methylene-phenol resins, by condensation of phenols (benzophenol; cresol; naphthol) and formic aldehyde (or its derivatives trioxymethylene, paraformaldehyde, hexamethylene-tetramine) in presence of condensation agents (chiefly HCl). There are several qualities in industry, viz., a substitute for shellac which is fusible and soluble in ordinary solvents, *e.g.*, laccaine, saliretine, medolite, &c. A second variety (amber substitute) is insoluble and infusible. This resin contains more formaldehyde and often a base (NH_3NaOH), *e.g.*, novolac, resinite, resite, bakelite C. Various formaldehyde resins are made by condensing formaldehyde with other compounds than phenol, such as methyl diphenylamine, naphthaline, &c. Coumarone resins are the products from condensation by SO_4H_2 of indene and coumarone, contained in heavy benzols (boiling at 160° to 180° C.). A great number of other reactions give resinous substances, *e.g.*, the action of formic aldehyde on lactic acid from which a bone-like substance is obtained. Likewise, the lignin from sulphite liquor in cellulose manufacture gives resins for which there are already uses.—*Chimie et Industrie*, July, 1921.

BOOKS RECEIVED.

"Bleaching." Being a *Resumé* on the important researches on the industry during the years 1908-1920. By S. H. Higgins, M.Sc. Pp. viii. +137. London: Longmans Green & Co. Price 10s. 6d. net.

"An Introduction to Organic Chemistry." By D. L. L. Hammick, M.A. Pp. vii.+258. London: G. Bell & Sons, Ltd. Price 6s.

"The Fixation of Atmospheric Nitrogen." By Joseph Knox, D.Sc. Second Edition. Pp. vii. +124. London: Gurney & Jackson. Price 4s. net.

"Botany for Students of Medicine and Pharmacy." By F. E. Fritch, D.Sc., Ph.D., F.L.S., and E. J. Sailsbury, D.Sc., F.L.S. Pp xi.+357. London: G. Bell & Sons, Ltd. Price 10s. 6d.

New Patents.

This List is specially compiled for the *Chemical News* by Messrs. Rayner & Co., Registered Patent Agents, of 5, Chancery Lane, London, W.C.2., from whom all information relating to Patents, Trade Marks and Designs can be obtained gratuitously.

Latest Patent Applications.

27196—Aquazone Laboratories, Inc.—Aqueous solutions containing oxygen, and methods of producing same. October 13.
26849—Mai, A.—Process for making arsenical solutions. October 11.
27188—West, H. J.—Manufacture of hydrogen or gases rich in hydrogen. October 13.
26681—Jones, H. Sefton.—Water soluble compounds of diethyl-barbituric acid and its homologues, and manufacture of same. October 8.

Specifications published this Week.

146411—Wehmer, C.—Manufacture of fumaric acid.
147067—Chemische Fabrik Rhenania Akt. Ges., Stuer, B.C., and Grob, W.—Manufacture of nitrogen containing addition and condensation products from acetylene and ammonia.
147094—Theile, J.—Manufacture of sulphuric acid.

Messrs. Rayner & Co., will obtain printed copies of the published specifications and will forward on post free for the official price of 1/- each.

NEW COMPANIES.

The under-mentioned particulars of New Companies recently registered are taken from the Daily Register compiled by Jordan & Sons, Limited, Company Registration Agents, Chancery Lane, W.C.2.

Booth & Openshaw (Blackburn) Limited.—(177365)—Registered October 20th, 1921. 17/19, St. Peters Street, Blackburn. To carry on the business of Chemists, Druggists, etc. Nominal Capital: £2,000 in 2,000 Shares of £1 each. Directors: W. W. Openshaw, Brooklyn Road, Wilpshire, Near Blackburn; I. Turner, 30, Watling Street Road, Fulwood, Preston. Qualification of Directors: One Share. Remuneration of Directors: To be voted by Company.

Chemical and Pulp Company, Limited.—(177392)—Registered October 21st, 1921. 595/596, Salisbury House, London Wall, E.C.2. To carry on the business of Dealers in Chemicals, Manures and Dyes, etc. Nominal Capital: £5,000 in 5,000 Shares of £1 each. Directors: W. S. Hopkins, 63, Stratford Road, Thornton Heath, S.W.; F. H. Johnson, 12, St. Wilfrid's Road, New Barnet, Herts. Qualification of Directors: £100. Remuneration of Directors: To be voted by Company.

MEETINGS FOR THE WEEK.

Monday, November 7.

Institution of Electrical Engineers, at 7. Discussion on "How best to speed up Electrical Progress."

Wednesday, November 9.

Royal Society of Arts, at 8. "The Work of the Industrial Fatigue Research Board and its Applications to Industry" by D. R. Wilson, M.A., Secretary of the Industrial Fatigue Research Board.

Thursday, November 10.

Optical Society, at 7.30. "The Path of Rays in Periscopes having an Inverting System comprising two Separated Lenses" by Dr. Alexander Gleichen. "The Interocular Distance" by Dr. James W. French. "Note on the Thin Astigmatic Lens" by T. Chaundy, M.A.

NOTICES.

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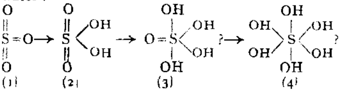
THE CHEMICAL NEWS.
VOL. CXXIII., No. 3213.

THE HYDROXYL RING.

By H. T. F. R ODES.

THIS question has already received some attention (Rhodes, CHEMICAL NEWS, 19 , cx .,), but only the general outline was considered, and it is now proposed to discuss with more detail the position of the hydroxyl ring in those salts which form hydrates, and which are wont to be described as possessing "water of crystallisation."

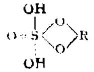
For reasons which will appear hereafter it is desirable to make allusion here to the addition products which sulphur trioxide forms with water:



(1) (2) (3) (4)

This is, of course, elementary except in the case of the last two compounds, $H_2SO_4.H_2O$ and $H_2SO_4.2H_2O$ the structures of which are doubtful, but to which allusion will again be made.

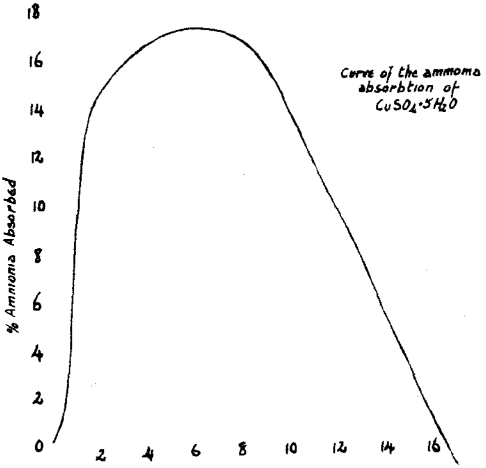
This hygroscopic quantity of sulphur trioxide will now be considered in relation to water of crystallisation. The author has already showr (Rhodes, La hygroscopisidad y el aqua de cristalisación, Universidad de Sevilla, 1920) that *all salts when deprived of their water of crystallisation are hygroscopic.* But it appeared probable that the mono-hydrates $XY.H_2O$ might be true hydroxyl compounds analogous to formula (3) above. This supposition—because of the higher dissociation temperature of most of the mono-hydrates—has frequently been advanced, but beyond this somewhat slender evidence, no additional facts in support of the structure



have been forthcoming.

This question was therefore made the subject of investigation (Rhodes, El Congreso de Oporto: Los aminos, los hidro-aminos y los hidratos del sulfato de cobre, July, 1921).

It is, of course, a well-known fact that acqueous vapour will replace the ammonia, group for group, in the compound $CnSO_4.5NH_3$; and it was thought not improbable that the behaviour of the pentahydrate of copper sulphate in the presence of dry ammonia gas might throw some light on the relation between the compounds $CuSO_4.5NH_3$ and $CuSO_4.5H_2O$.

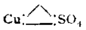


The action of dry ammonia gas on the penta hydrate proved to be interesting. The salt gained in weight until a compound corresponding to the formula $CuSO_4.5H_2O.3NH_3$ was obtained. The ammonia then began to replace the hydroxyl. The final product proved to be the well-known tetrammino mono hydro cupric sulphate $CuSO_4.4NH_3.H_2O$.

This would seem to make evident the structure of the monohydrate of copper sulphate. Water

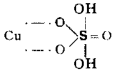
s known to replace all the ammonia in the ɪentammine, but ammonia, under the same condiions can replace but four molecules of water.

It has been shown that the formula of the pentımmine cupric sulphate may be represented by ıe structure



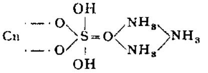
Rhodes, El Congreso de Oporto, *loc. cit.*).

But the pentahydrate cannot be analogous to ıis, since only four hydroxyl groups are ɛplacable by ammonia. The formula must thereıre be represented thus:



In considering the possibilities with regard to ıe position of the hydroxyl ring it is ɛcessary again to consider the compound $uSO_4.5H_2O.3NH_3$.

This triammino pentahydro cupric sulphate ould not be formed if the ammonia were assoated with the hydroxyl ring, since under these rcumstances direct substitution, without the forıation of an intermediate, would result. The rmula of this compound must therefore be



It must be admitted that this evidence in favour the position of the hydroxyl ring is not conısive, but it is, nevertheless, not founded upon ɪre hypothesis. The validity of the evidence ɪts upon the existence of this triammino pentadru cupric sulphate which is an extremely unɦle colloidal compound; but instability does t render unjustifiable an assumption as to its ucture, and its ammonia content corresponding, it does, to $(3NH_3)$ supports, although it does t definitely substantiate, this view. The forman of these colloidal hydroammino compounds also an indirect but interesting confirmation of ː work of Kuniloff (*Ann. Chym. Phys.*, 1906, i., 568). Allusion has already been made to ː fact that the assumption that the hydroxyl ɡ divides the anion and cation is in general reement with the conclusions that Ephraim and lle and Ephraim and Millman (*loc. cit.*) appear have arrived at.

But this does not dispose of a large number of er hydrates the question of whose structure has ɜady been discussed (Rhodes, CHEMICAL NEWS, . *cit.*).

t has seemed desirable, in agreement with Leod Brown (CHEMICAL NEWS, No. 2833, cix.,) to dismiss as improbable a structure which umes that the hydroxyl ring is attached to the gen atom of the anion; as well as the "gravitaıal" theory, which was, at best, a clumsy ɪothesis.

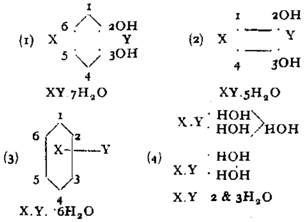
'he theory of Kohlrauch (*Proc. Roy. Soc.*, 5, lxxi., 338) concerning the mechanical retenı of some metallic ions within a "shell" of er seems therefore the most satisfactory hypoɪis, and its application to those hydrates conıing six or twelve molecules of water seems natural and plausible.

In the present state of our knowledge, therefore, it is necessary to accept the trial hypothesis that in these cases where the hydroxyl ring does not separate anion and cation, the metallic ion is retained within a ring or shell of water.

This is an interesting view since it seems not impossible that the hydrolysis of some salts such as the chlorides of aluminium and magnesium may be effected by the presence of this hydroxyl. The abnormal behaviour of chromium and aluminium salts upon electrolysis is also possibly due to the structure of their hydrates; it is hoped that this matter will receive consideration later, but the data available at present are not sufficient to merit special notice at this time.

Conclusions.

It is only necessary to add that four classes of hydrates are now recognised:



It will be found possible to classify the greater number of hydrates in this way. There are, of course, exceptions, some of which have already been considered; these, however, are not numerous, and, when more data are available, they will receive special consideration.

Note.—The author wishes to express his thanks to Miss I. Watt, Member of the Pharmaceutical Society, and to J. H. Jackson, Esq., J.P., both of whom made it possible for him to complete his work for the Congress of Science held at Oporto in July of this year. Through circumstances over which he had no control, the writer was compelled to cut short his work at Seville University, and to complete that which remained to be done in England, under conditions of some difficulty. Both of the above most kindly lent the writer apparatus, and in general rendered him most valuable assistance.

ROYAL INSTITUTION.—A General Monthly Meeting of the Members of the Royal Institution was held on the 7th inst.), Sir James Crichton-Browne, Treasurer and Vice-President, in the Chair. Dr. W. A. Bond was elected a Member. The Special Thanks of the Members were returned to Mrs. Williams for her gift of personal notes of Davy's Lectures at the Royal Institution made by Thomas Harrison (Secretary R.I. 1818-24) and 22 books of the Works of Cicero, Horace, Hippocrates, and Waring, formerly in his possession. The Chairman reported the deaths of the Earl of Ducie, Mr. J. H. Balfour-Browne, and Professor G. Lippmann, and resolutions of condolence with the families were passed.

THE GRAPHICAL REPRESENTATION OF CERTAIN HETEROGENEOUS EQUILIBRIA.

By A. C. D. RIVETT.

THE ordinary graphical representation of solubility relations of solids (that is to say, of equilibria between solids and solutions) implies certain conclusions which cannot be justified.

In numerous text-books and treatises on the Phase Theory, as well as in original memoirs, it has become customary to represent binary systems, usually examined under an arbitrarily selected pressure sufficiently great to prevent vapour formation, by composition-temperature diagrams, of which Fig. 1 may be taken as a type

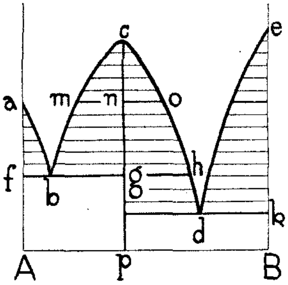


FIG. 1.

Percentage compositions (by weight, atom, or molecule, as may be preferred) are plotted along the axis of abscissæ, the respective ends of it represeuting pure component A or B. A point such as p indicates a mixture, or may be a compound, of which pB per cent is component A and pA per cent is component B. Temperatures are plotted along the axis of ordinates.

The curve *ab* (or *ed*), termed a "solubility curve," gives solutions commonly stated to be in equilibrium with solid pure A (or B), that is, with a solid represented in composition by any point on the vertical line *af* (or *ek*). Any mixture of mean composition corresponding with a point in the area *afb* (or *edk*) will separate into pure solid A (or B) and a solution on *ab* (or *ed*).

Now in discussing the question of the immiscibility or otherwise of metals in the solid state, Alkins has pointed out (in a communication not yet published) that the Phase Rule requires variation in the solid phase in binary systems to correspond with variation in the liquid phase. The argument is that as a condensed binary system in two phases can have but one degree of freedom, therefore, with any selected solid, say pure A, there can be only one liquid in equilibrium, and that at only one particular temperature. For any other liquid the solid must have another composition, and the temperature must be different.

This conclusion is quite general. The "solubility curve of a component" is not what the description implies. The curve gives compositions of a series of solutions each in equilibrium with a separate, distinct solid. The variations in composition of the solid may be slight, but they cannot be zero. Particular cases will differ in degree only. This, which applies to the curves *ab* and *ed* of Fig. 1, applies equally to any intermediate curve such as *bcd*. *bcd* would generally be described as the curve giving all solutions which can exist in equilibrium with a definite solid compound having the composition of the turning point *c*, that is to say, with a solid represented by any point on the vertical line *cp*. If, however, it were this, it would follow that solutions *m* and *o*, for example, being each in equilibrium with the same solid (*n*), would be able to exist in equilibrium with one another. As a matter of fact, they cannot do so. In whatever proportions these liquids be brought together, a phase reaction always occurs giving a solid and more or less (in one case, none at all) of a single liquid of the same composition as one or other of them. Or again, if the interpretation quoted were correct, there would be a range of selection of temperatures at which three phases (two liquid and one solid) could co-exist. This, however, is impossible, since a three-phase condensed two-component system is invariant. Nor is it possible, as the diagram suggests, for four phases, namely, solid A (*f*), solid *p* (*g*), and the liquids *b* and *h* to be in equilibrium under an arbitrarily selected pressure.

It follows that the correct form of the general or typical diagram is of the type shown in Fig. 2.

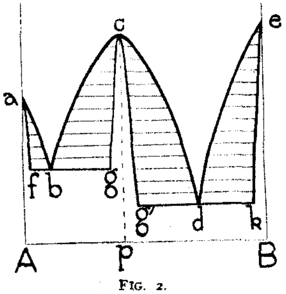


FIG. 2.

This shows that the composition of the solid phase (represented along the curves *af*, *gcg'*, or *ek*, as the case may be) varies, however little, as the composition of the liquid phase (represented along *ab*, *bcd*, or *de*, respectively) varies. Incidentally it follows that *c*, the turning-point, is only one of a series of varying solids, though one that is unique in that it has the same composition as the liquid with which it is in equilibrium, this being the necessary condition that the curve shall have a turning-point. It follows, too, that the solid which separates out during cooling of a solution saturated at an upper temperature will not be of uniform composition. The range of variation may or may not be large.

An argument quite similar in kind may be applied to ternary systems. The usual representation of a typical condensed isotherm is given in Fig. 3, where, say, A is a solvent and B and C are solid salts. B and C are assumed to form, in integral molecular proportions, a "double salt," or compound, D.

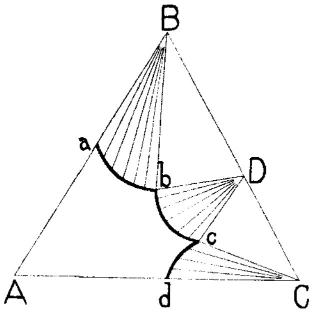


Fig. 3.

There are three curves, *ab*, *bc*, and *cd*. Now, if the system be quite rightly represented here, D, say, can be in equilibrium with a number of solutions of different compositions ranging from *b* to *c*. Therefore all such solutions must be able to exist in equilibrium with one another—an obvious absurdity. Or again, D can exist with solution *b* and solid B; also with solution *c* and solid C. Hence the five phases represented, respectively, at B, D, C, *b* and *c* can exist together in a condensed system at the arbitrarily chosen temperature of the isotherm. This is in contradiction to the Phase Rule. There cannot be more

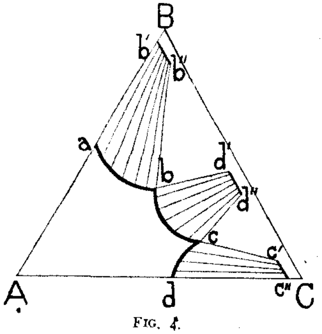


Fig. 4.

[th]an three phases in equilibrium in a ternary [sy]stem if temperature and pressure be arbitrarily [fi]xed.

The Phase Rule, in fact, requires for this case relations such as are diagrammatically represented in Fig. 4.

Instead of the solid phases in equilibrium, respectively, with solutions along the curves *ab*, *bc*, and *cd* being represented by points B, D, and C, they must be represented by lines *b'b''*, *d'd''*, and *c'c''*, however short these lines may be; and since of course the component A also must enter into these solids, these lines will lie wholly in the ternary region except that one end of the first (*b'*) and one end of the last (*c''*) will be on the corresponding binary sides of the triangle. This then will show that there is a distinct composition of solid for every composition of liquid.

A similar argument may be applied to higher systems. Variation of solid phase with variation of liquid is the general rule, and this may be stated also in the form that mixed-crystal (or solid solution) formation is general in the solids which separate from solutions. Considerations of like kind hold, of course, for phase equilibria between solids only. It is advisable not to overlook these facts in our customary diagrammatic representations of heterogeneous equilibria, since to do so implies relations which are impossible.

Chemistry Department,
University of Melbourne.
September 2, 1921.

THE CHEMIST IN THE STEEL AND IRON INDUSTRY.

A Few Thoughts on his Experiences, Training, Status, and Influence on Manufacture.

By C. H. Ridsdale.

When you did me the honour of inviting me to give you an address, and, whilst leaving the subject open, intimated that "some reference should be made to the status of the chemist in the steel industry as it stands to-day," I felt at once that this subject itself might be worth your consideration, and that you would perhaps bear with me if, instead of giving you something technical or formal, I simply submit for your consideration a few thoughts which have been borne in on my mind from time to time in the course of my life experiences, and as to which I shall hope to learn your views in the discussion.

I suppose most of you are works' chemists—many of you in iron and steel works—and if so, you are a body of men for whom I have always had a very warm place in my heart, for although my early chemical training was in a public laboratory under Dr. Stead, and I am again back into public practice, for the intervening 37 years I was a works' chemist in the iron and steel industry, so I can claim to be one of yourselves.

In that capacity I have had the engaging and training—so far as the limited conditions of works practice permit it—of a very large number of young chemists, and have followed every detail of their progress from the boy who has just left school, onward until he has in many cases become a highly competent chemist or works' manager.

Many of you are young men setting out to

*An address given to the Glasgow Branch of the British Association of Chemists, October 19, 1921.

climb the ladder to fame, and I shall feel it a privilege as well as a duty if anything I can tell you will enable you to improve your position and get fuller value out of life. You can be sure I am not theorising, but giving you conclusions drawn from my own experience in a practical life, under conditions where no attempt was made "to temper the wind to the shorn lamb."

A chemist instinctively, whether conscious of it or not, analyses not only materials, but ideas and pretty well everything which comes under his observation, and, true to his instinct, whatever he finds he feels bound to report, no matter where the results lead to. This is because he who is truly a chemist at heart, and has not simply been pitchforked into it, or taken it up with the idea that it is "a nice soft job," is essentially a seeker after truth, and to a large extent, an idealist.

Mr. Pilcher, Registrar and Secretary of the Institute of Chemistry, in a book he has published, quotes Beecher's description of chemists as "a strange class of mortals, impelled by an almost insane impulse to take their pleasure among smoke and vapour, soot and flame, poison and poverty . . . . . . One singular resemblance between Holy Orders and the practice of Chemistry—the practitioner is supposed to receive part payment from his temperamental delight in the subject itself."

This seems to me an apt description, and was particularly so of the chemist in the basic Bessemer shop, though in open-hearth plants, and with the present better pay, it loses some of its cogency.

Still, the chemist is often regarded by the other men in the works with a certain amount of awe, and as being associated with mystery; just as the alchemist in the old days was—like Faust, generally associated with the devil.

In my earliest steel-works experience the laboratory was known as "The Doctor's Shop," and although this designation had reference primarily to the bottles and coloured liquids, yet it soon justified the appellation, for as there was no ambulance installation, we got a collection of lint, bandages, sticking plaster, carron oil, &c., and gave first aid in cases that were not too serious, and in one year of which I kept a record, we treated 1000 cuts, burns, scalp wounds, &c. Nor was it altogether unknown for a chief chemist to keep quinine, toothache mixture, cocaine, and a few other simple medicaments for assistants having slight ailments but not wanting to leave their work.

And this reminds me that one of the most pleasing features of the chemist's profession is the wonderful variety of experiences to which it may lead. What a romance there is in the life if the proper attitude of mind is maintained! What a number of avenues open out! Why, it has never seemed to me that even a pirate's life had the glamour that a chemist's offers. And surely horse-racing cannot offer more thrills than the intensely eager interest with which one awaits the result of the referee chemist's finding in an important dispute case.

I dare not commence to give you any of my own reminiscences, or I should go on too long and weary you. But to get this feeling of romance, one must take the right interest in one's work. The man who takes a keen interest in, or is enthusiastic about his work, not only turns it into a sport, but materially adds to his own worth.

Every employer values one who does so much more highly, and will, when it comes to a test, give better pay or privilege to retain him.

There is, of course, some monotony and drudgery. All work has it. In fact, nothing really great is achieved without it. Remember, "*Per Ardua ad Astra.*" Works' chemists have great responsibility; for instance, even junior assistants are held responsible for the passing on their analyses of large casts of steel, a single one of which during the war might be worth £1,000.

The work of the chief chemist may cover an enormous range which I cannot attempt to enumerate, but they have to deal with the acceptance of raw materials and the passing for despatch of manufactured materials which in one year may be worth millions of pounds, and have also the technical control throughout manufacture. It has seemed to me that on the Continent their importance is generally more fully recognised than here, and their position ranks higher. I doubt if anyone gets a more thorough knowledge of what is going on througbout a works than the chief chemist.

Chemists have to deal with materials and forces—and use them as tools or weapons—which may be very dangerous if handled carelessly, though they are not dangerous if handled with proper knowledge and judgment. It is the *balance* and correct sense of proportion acquired by the nature of their training which should render their influence so valuable as they mix in the world, and which should automatically become disseminated amongst those around them.

Meanwhile, I think you will all agree that chemists not only are of great use in the world, but could be of still more use if it would learn how to avail itself more fully of their services, and they must try to show it how to do this.

You will, I feel sure, agree too, that the status ought to be improved. Let us see exactly what status means.

My dictionary—and therefore, of course, the best—defines it as "condition, social standing or place, rank." You will note it is not primarily a question of money—and I think for our purpose *it might be expressed as the good opinion or value which others spontaneously accord*—for you cannot force spontaneous good opinion.

Now the chemist's value is not simply measured according to his *technical* ability. One great value, inculcated both by the essential nature of his training and occupation, is the *attitude of mind* which these, perhaps more than in any other profession, tend to induce and develop—precision, accuracy, reliability, truth, and resourcefulness. In short, his mental attitude may be one of the main factors in the improvement of the status of the chemist.

The power and value of a right mental outlook and of other things which may seem irrelevant have been realised more and more of late by hard-headed practical men, hence we now have all sorts of psychological questions which a few years ago were rarely mentioned or thought of as connected with business, seriously studied and set forth—for example, questions of fatigue, and welfare work generally.

As this address has for its primary object the

welfare of the iron and steel works' chemist, I ask you to bear with me in my mention of some of such questions.

I suppose, looked at broadly, each of the chemical societies aims at doing a sort of welfare work for the particular section it represents. I only give a brief impression of the outstanding features which differentiate them.

The Chemical Society, by eliciting, collecting, and publishing for the use of its members, papers, new facts, and researches, covers practically the whole range of pure chemistry.

The Society of Chemical Industry by doing the same, chiefly with regard to the *industrial* application of chemistry.

The Society of Public Analysts devotes itself mainly to the progress of *analytical* chemistry.

The Institute of Chemistry, being "primarily a certifying body (*Proceedings*, Part II., April, 1918, p. 39), as such seeks to elevate the profession; *first*, by setting up a particular standard for admission, which it expects will obtain from the public, recognition that its members are of a somewhat higher status than those who are not members, and, as a gauge for which, it holds examinations; *secondly*, by indicating a precise course of training which prospective candidates should undergo to fit them to meet that standard; and *thirdly*, by suggesting minimum rates of payment for certain positions, keeping an appointments' register, and in similar ways endeavouring to benefit members financially. Those who wish to be regarded by the Institute as reaching its standards are required to present themselves for examination, or to satisfy it in some other specified way.

As regards these methods, the *first* especially, seems to me to entail a difficulty which might be compared to that met with when using a square-meshed sieve to separate small material from larger; a great deal of small is removed, but also it often happens that an appreciable proportion of pieces which have quite as much volume and weight as the average piece left on—and sometimes more— are not retained, but rejected with the small, just because they are of a less usual shape than the average lumps.

They may even be pieces two or three times as long, and heavier than more cube-shaped pieces retained, but they are lost just because they were undersized in one particular dimension, and would perhaps just go through corner-wise. So too, on the other hand, in spite of careful sieving, a certain number of pieces *smaller* than are wanted are inevitably retained.

It would seem quite reasonable from its own stand-point that any society should make its own rules for admission to it, and for gauging the qualifications of prospective members, but when it seeks, or tends to become, a measure of qualifications generally in that particular line, then those who believe themselves to be equally qualified, but for reasons which they consider adequate, do not or cannot comply with the prescribed conditions, perhaps not unnaturally feel aggrieved, as they are subjected automatically to an implication of lower status. I know this is the view of some industrial chemists holding important positions. Thus, in the Institute's case, having a Charter, and its dictum carrying a certain weight, it naturally draws criticism not directed to societies the procedure of which does not bring about similar differentiation. This is the more so because there are some members who would go even further, and strongly advocate making analytical chemistry a close profession.

(To be continued

TRAINING FOR FOREIGN EXPLORATION.*

By H. FOSTER BAIN,
Director United States Bureau of Mines.

(Concluded from p. 245)

MINERALS are the raw materials on which are based numerous industries and the conditions which limit their use are the same in many particulars as are those which unduly aid industry in a given region. Security of title, stability of government, availability of labour, adequacy of financial support, these are all matters to be considered by economists. Here again the exploring engineer may to his own advantage draw on a fellow professional for methods and data. His own training prepares him to judge as to the material. Matters concerning men and money are, however, equally important, since the test of his results is whether he has found something which may be produced with reasonable expectation of profit. The subject is too large for discussion here. I may merely mention a few items by way of illustration.

One of the assumptions too commonly made is that low wages necessarily means cheap production. This may or may not be true. It is largely a matter of efficiency. It it requires, as it sometimes does, six miners of one race to do the work of one of another, it must be clear that paying wages in the ratio of one to six does not lower costs. Not only that, but the final cost of production with such "cheap" labour will be higher because of the larger number of working faces necessary in the mine, greater amount of equipment, the extra supervision and housing, the higher accident ratio and other matters, all of which enter into the final cost. On the contrary, one must not conclude that raising wages cheapens production. It only does so when increased efficiency results from the added desire on the part of the men to hold their jobs, or when it enables a particular employer to attract the better men from others. Generally, added efficiency in labour is purchased at an increased cost per unit, just as the added speed of a fast steamer calls for more coal per mile than when driving at a slower rate. It is also to be remembered that there are natural inequalities in efficiency and in the economical rate of speed of work as between men. These can only be changed slowly. Another factor to be constantly kept in mind by the engineer is that one of the costs of a new enterprise is that of attracting labour to it from existing industries. It may usually be safely assumed that the people of any district are already employed. If they do not work they generally starve. What they are doing may seem relatively unimportant to the visitor, but it assumes another

* Forty-eighth Annual Commencement Address, delivered on April 29, 1921, and reprinted from the *Bulletin* of the School of Mines and Metallurgy, University of Missouri, June, 1921, No. 3, vol. xiii.

aspect to them. It is necessary either to import men already accustomed to the industry, usually at material expense, or to tempt workers out of some other line into the new one, and then to train them to it. This requires both time and money. The importance of the time factor arises from its effect on the present value of proposed investment. To illustrate: deferring the initial returns for two years decreases by 14 per cent the present value of a series of dividends running through 20 years at 8 per cent, assuming accumulations at 3 per cent. The actual result varies with the assumption of time and rate, but the essential fact is that mere delay is expensive. When this delay is coupled with upkeep charges it is even more serious. This whole matter of the possible and probable rate of continuity of production is one of first importance in determining the availability or value of any mine or prospect. Into it enters also the various questions of market. I have already indicated my reasons for believing that, whatever may be the depressing facts of the immediate present, we may safely assume a continued demand for metals. This demand will, however, vary from time to time both for the group as a whole, such variations being due to general causes outside the industry itself, and also as relates to each metal. It is necessary to study problems such as expansion of use, substitution, periodic demand, and similar matters far aside from ordinary class-room instruction. As regards a particular enterprise, it is necessary in fixing capitalisation to make assumptions not only as to the probable average price of output during the life-time of the investment but also the maximum and minimum to be assumed, the probable period of duration of each, and if, as is occasionally true, some guess can be made as to the impending swing of the pendulum, it will be of great assistance. A property is financed on the basis of average returns through an expected life determined by consideration of numerous factors. A company in which capital is so adjusted to income may nevertheless fail if not prepared to withstand a temporary period of low prices, while if high prices may be safely assumed in the near future it is possible to finance the enterprise from earnings to a considerable extent. There is one general rule—the old one, that a "bird in hand is worth two in busb." This is sound, not only because of the risk attached to the question of acquiring the two theoretically in the bush, but because the one in hand, if a good hen, may lay eggs through the waiting period. The dollar of to-day is worth more, normally, than the dollar which is to be paid some years later because it may earn for you interest meanwhile. This principle of the greater value of quick returns when astutely used is a great help in bargaining.

It happens that there are many minerals that are only of important value when properly related to others. Iron ore, coking coal, and limestone form a trinity. Nothing is of less value than a large deposit of pure iron where it cannot be used. The value of iron ore is less a matter of the extent and composition of the deposit than the assembly cost of raw materials at a suitable point for making pig iron and steel. Such matters seem, possibly, far from the province of the exploring engineer, but all around the world are wrecks of business enterprises where money was spent to find and develop raw materials without adequate study of competition and market conditions. The exploring engineer who disregards such problems limits his usefulness and the rewards that he may expect.

Just as any engineer starting for a far country carries in addition to instruments, food, and engineering supplies, a personal kit, so there are accomplishments that are as desirable if not necessary to the exploring engineer as his knowledge of mathematics and geology. He must know how to keep himself and his men in good health or his expedition will fail. He is the scout of industry and often the pioneer of civilisation. When he goes into the wilds the health risk is often the greatest personal danger faced. Even when he goes to older settled countries the conditions of life differ from those in his own home, and care is necessary. With care it is possible to live and work in almost any country. It is now known that where it is worth while to do so, even tropical jungle lands may be made safe and sanitary. To do this involves heavy expenditure not warranted in exploration, so that the pioneers assume risks not necessarily met by the operating forces that come later. The exploring engineer would do well to look carefully to his own physical condition, and watch closely the food, drink, and habits of his party. Learn and enforce proper rules as to camp sanitation. One careless man may wreck an expedition or cause long and expensive delays. It is generally true that the most suitable food is the food of the country, but the exceptions are numerous and the cost of a mistake serious. Until the facts in each instance are established, it is a justifiable expense to use imported foods. Proper cooking will render foods otherwise dangerous safe, and moderation in eating strange dishes is a wise precaution. The American habit of drinking raw water is one to be indulged with discretion in regions of older civilisations, but safe water is easily obtained by boiling. It is worth while to pay attention to details such as these which seem small to those accustomed to our own ways of living. A knowledge of the methods of first aid and a few medicines is of great value. It is not necessary to go as far as Doc Milliken who, as you may remember, would "take that bracket saw and the mild chloride and his hypodermic, and treat anything from yellow fever to a personal friend," but a little knowledge of simple medicines will ease your way greatly in strange countries. Learn to ride, to shoot, to swim, and to handle a small boat. I need hardly admonish a young American these days to learn to run a motor-car, but the accomplishments common in the older days of country and village life are becoming rare. It is not always possible to ride up to a prospect in a Pullman or even in a Ford. In the nature of things, the finding of new mines will take one into countries where only other than mining industries have been developed, and in practice that means going into regions of country and village life. At times it means rolling back the centuries and living for awhile in the mediæval ages. In such places one must know about horses and mules—their habits, preferences, food, simple ailments, and capacities for work. One may, too, be called upon to use a gun, though far more probably to afford the party fresh meat

than as a means of protection. To handle a boat or to swim may be a necessity at any time, though it must be admitted that in any country where small boats are used native boatmen are likely to be numerous and skilful. Skill in any of the forms of what we now call sport may well prove of first importance in an emergency and will always prove at once a means of relaxation and of establishing relations with strangers, regardless of race and language. The latter is a matter of no small importance in work when the goodwill of the whole party and of the people of the country traversed is so important.

Lastly, I would urge that to be successful one should have something of the spirit of adventure. Unless new scenes and new faces appeal to you, unless you find joy in the long days in the saddle or afoot, unless the cheer of the camp fire means more to you than the clank of the steam radiator, unless to you coffee does not lose its fine flavour when served in a tin cup, unless you can sleep between blankets and not think of their scratching, do not undertake exploration. If you must have a napkin and morning paper at breakfast, if you cannot write save at a well-equipped desk, if you are not happy except with your family and intimate friends, if you must needs see the movies before you can go to bed at night, you will be wise to find a routine job at home. But to those who have a venturing nature adventures come, and if you are one of the elect who feel the spell of the Yukon, or the lure of the little voices, then go

"Adventuring! Adventuring! And oh, the sights to see
And little fires along the trail that wink at you and me,
Till the last adventure calls from the old, the vain desires,
To a way that's still untrodden, though aglow with little fires,
Where no wanderer grows weary and a man is free to roam,
Or hang his hat upon a star and call the planet home."

NITROGENOUS MANURES.

The Action of the Manures.

NITROGENOUS manures have more striking effects than any others in increasing the growth of farm crops. Under normal circumstances a dressing applied at the proper time produces visible results almost in a few days: the plant becomes greener, stands up well, and starts into growth, while the untreated portions of the same crop are unchanged. It has often happened that a dressing of 1cwt. per acre of nitrate of soda or sulphate of ammonia has given an additional 4 bushels of wheat or 6 bushels of oats.

Experience has shown that nitrogenous manures are effective in several directions.

1. *On Winter Corn after a Wet Winter.*—In this case a top-dressing of 1 to 1½cwt. per acre of nitrate of soda or sulphate of ammonia should be given in spring as early as convenient. One must not, of course, go on to the land until it is sufficiently dry to bear the distributor without injury, nor should the manure be applied to winter corn in frosty weather; an opportunity should be found, however, at the end of February or early in March. If the land is sticky, 1cwt. of superphosphate per acre should be applied in addition.

There has been considerable discussion as to the most suitable quantity of nitrogenous manure to use for spring dressings for winter crops. It was formerly supposed that the most profitable returns were obtained from small dressings: more recently, however, it has been shown that moderately large dressings are more profitable—1½cwt. of nitrate of soda or sulphate of ammonia giving not only a larger, but a more profitablle crop than ¾cwt. per acre.

2. *On Spring Oats, especially in Wet Weather, or in Cold or Backward Districts.*—In this case it is necessary to add superphosphate as well: the dressing would be 1cwt. nitrate of soda or sulphate of ammonia, and 2½cwt. superphosphate per acre; or if the conditions allow of heavy crops, 1½cwt. of nitrate of soda or sulphate of ammonia, and 3cwt. superphosphate per acre.

3. *On a Second Corn Crop.*—Farmers are often so anxious to avoid overmanuring their barley that they grow it as a second corn crop after wheat or oats. It frequently happens, however, that an additional yield can be obtained without sacrifice of quality by means of a moderate dressing (¾ to 1cwt.) of sulphate of ammonia, combined if need be with 2cwt. superphosphate per acre.

4. *For Potatoes and Mangolds.*—These crops practically always benefit by the use of nitrogenous manures, even when dung has been applied on a fairly liberal scale: potatoes commonly respond to 1 to 2cwt. sulphate of ammonia applied at the time of planting, while mangolds can do with the same amount of nitrate of soda, half being given when the plants are up, and half at the time of singling. Swedes and turnips, however, are less certain in their response, and frequently farmyard manure alone proves as effective as anything.

5. *Hay* practically always responds to nitrogenous manures (1½cwt. per acre), though the quality suffers unless potash and phosphates are also added.

What the Manures are.

Nitrate of Soda.—This is the most rapid in action of the nitrogenous manures in common use, and it has repeatedly proved effective in encouraging growth in a cold spring when the young crop is beginning to turn yellow.

The speedy action is of great advantage in helping a crop over an attack by insects or wireworms; the additional nitrogen enables the plant to keep growing and thus to replace the tissue destroyed by the insects. But while nitrogenous manure is of value against insect pests it does not help against fungi; a soft sappy growth tends to develop which readily succumbs to fungus attacks.

Besides being the most rapid in action, nitrate of soda is in general the most effective, except for potatoes, for which sulphate of ammonia is better. For winter corn and for hay, nitrate of soda is about 5 per cent more effective than sulphate of ammonia; for mangolds the difference is even greater as the soda is distinctly helpful to the crop. It has the drawback that it cannot easily be used on heavy soils as it tends to make them sticky, thereby increasing the difficulty of working; further, it is not required on fen soils. Otherwise it can be used on all classes of soils, even those which are deficient in lime.

Nitrate of Lime is as quick in action and as effective as nitrate of soda, but it is somewhat less convenient in use owing to its tendency to take up moisture which necessitates transportation in casks. It has the advantage, however, that it can quite well be used on heavy land without pro-

ducing the stickiness caused by nitrate of soda.

Nitrate of Ammonia is not generally obtainable at present, though it is understood that its manufacture is being undertaken by an important industrial organisation. It is more rapid in action and more concentrated than either of the preceding fertilisers, but it is also less convenient, tending to cake rather badly, and requiring to be stored always in casks.

Sulphate of Ammonia became very well known to farmers during the war from the circumstance that it is a home-made product, and was therefore obtainable long after the imported nitrates were out of the farmers' reach. Taking a general average of soils and of crops it is about 5 per cent less effective than nitrate of soda when applied on an equal nitrogen basis. It is, however, more concentrated than nitrate of soda, and this more than balances its reduced efficiency, so that for equal weights it is often superior. Thus, if a farmer can buy sulphate of ammonia at the same price per ton as nitrate of soda he will in many cases save money by doing so; but if the prices are not the same, he must work out the unit price from the data given below. These statements as to averages require considerable modification when one deals with particular soils. On chalky land, sulphate of ammonia is practically equal to nitrate of soda in effectiveness; on clay soils it is preferable as it does not cause stickiness. But in peat soils and on sandy soils deficient in lime (as many of them are) it is unsafe until sufficient lime has been added: there have been cases, notably at Woburn, where sulphate of ammonia has done actual harm to the crop through its property of inducing acidity in the soil. (The remarks as to acidity apply to the use of ordinary sulphate of ammonia, which is slightly acid. A 'neutral" brand of less than 0·025 per cent acidity is now obtainable in certain districts, which possesses the further advantage of being drier and in better condition for distribution). The trouble can be entirely remedied by a dressing of lime, which in any case is desirable on light soils. Potatoes and oats are less affected by this acidity than other crops, indeed potatoes gain rather than lose since the scab is thereby kept in check. Any scheme for adding lime to counteract the acidity should be brought into operation just after potatoes have been removed and just before clover is to be sown.

Muriate of Ammonia.—It is probable that this substance will be produced on a large scale in England at an early date, and careful experiments have been undertaken to ascertain its precise fertiliser value.

Nitrolim.—This substance was carefully tested as a fertiliser before the war, and found to be somewhat inferior to sulphate of ammonia, besides being slower in action; further, it is not suited for top-dressings. Experiment has shown that it is not immediately available for plants, but has to undergo decomposition in the soil. It seems probable that the decomposition could usefully be brought about in the factory, thus giving a product that would be more rapid and effective in action and suitable for top-dressings.

Storage of Nitrogenous Manures.

The keeping qualities of nitrate of lime and nitrate of ammonia have been referred to above. Both should be kept in a dry place in the original casks. After the packages are opened, these manures cannot well be stored. Nitrate of soda may be kept for a considerable time under dry conditions in a well-built shed. It may become lumpy owing to the action of moisture and must then be crushed. Sulphate of ammonia is best stored in bags placed on planks or on a layer of peat rather than on the bare earth or a brick floor. The building in which it is stored should be dry and free from damp. The well-made "neutral" sulphate is less affected by moisture than the ordinary quality. If sulphate of ammonia should cake, it should be broken up with a wooden crusher.

Table showing Percentage of Nitrogen in the Ordinary Nitrogenous Manures.

Substance	Per cent. nitrogen usually present.
Nitrate of soda	15½
Nitrate of lime	13
Nitrate of ammonia	34½-35½
Sulphate of ammonia	20¾
Muriate of ammonia	25
Nitrolim	14½-15½

Under the Fertilisers and Feeding Stuffs Act, the percentage of nitrogen in a fertiliser must always be stated in the invoice: percentages of ammonia, sulphate of ammonia, &c., should be disregarded.

It is imperative that nitrogenous manures should be in fine condition before being applied to the land: any lumps should be sifted out and broken with a wooden rammer. Modern sulphate of ammonia of the "neutral" brand is often in better condition than the older material.

Of the manures described above, sulphate of ammonia and muriate of ammonia are the only ones which can readily be mixed with superphosphate. Where necessary nitrate of soda and superphosphate can be mixed provided both materials are dry and the mixture is used at once.

—Ministry of Agriculture, Leaflet No. 370.

PROCEEDINGS OF SOCIETIES.

ROYAL SOCIETY.

Ordinary Meeting, November 3, 1921.

PROF. C. S. SHERRINGTON, President, in the Chair.

THE following papers were read:—

"Spectra of Lead Isotopes." By T. R. MERTON, F.R.S.

A comparison has been made of the wave-lengths of five lines in the spectra of ordinary lead and lead from Australian carnotite. The differences in wave-length which have been observed are not constant, but vary for the different lines. In the case of the principal line, $\lambda = 4058$ A, the difference in wave-length observed is about two hundred times as great as would be expected on theoretical grounds.

"Experiments with Rotating Fluids." By G. 1. TAYLOR, F.R.S.

Experiments in which spheres, cylinders, and vortex rings move through rotating fluids have previously been described by the author. Methods

are now described by means of which the experiments can be projected in a lantern. Instantaneous photographs taken while the experiments were in progress are shown.

Further experiments are described in which predictions from hydrodynamical theory are verified. It is shown that if any small motion be given to a rotating fluid, the resulting flow will be of such a nature that concentrated masses of coloured liquid should be drawn out into thin films, which should remain always parallel to the axis of rotation. Photographs taken by a camera placed vertically above a rotating basin of water show that a liquid does actually move in the way predicted, the films of colouring matter appearing as thin lines to an eye situated on the axis of rotation. These sheets of colouring matter may become so thin that it is only possible to see that the colour is not uniformly diffused through the liquid by placing one's eye on the axis of rotation.

"The Two-dimensional Slow Motion of Viscous Fluids." By L. Bairstow, F.R.S., Miss B. M. Cave, and Miss E. D. Lang.

The paper is part of a general investigation of the solution of the equations of motion of a viscous fluid. In its restricted form the equation to be solved is $\nabla^4\psi = 0$, where ψ is Stokes' stream function. The boundary conditions are those which give no relative motion between a solid and fluid in contact with it. If the molecular rotation in the fluid be defined by $\xi \equiv \nabla^2\psi$ it will be seen that the equation of motion may be expressed alternatively as $\nabla^2\xi = 0$. An earlier paper by one of us shows how, for certain boundary conditions, an equation of the type $\nabla^2\xi = 0$ may be solved in terms of simple sources distributed round the boundaries. An extension is easily made to cover the representation in terms of doublets, the finding of the strength of which has been the object of the present analysis.

The equation $\nabla^4\psi = 0$ is transformed by means of Green's theorem to a form in which the only unknown is the distribution of the ξ doublets on the boundaries. The strengths of the doublets is found by solving the resulting integral equation.

An example shows the motion of fluid past a circular cylinder in an infinite parallel-walled channel. Stream lines and lines of constant molecular rotation have been drawn. If d be the diameter of the cylinder, ρ the density of the fluid, ν the kinematic coefficient of viscosity, and U the velocity of the fluid in the centre of the channel at infinity, then, when the width of the channel is $5d$, the resistance per unit length of cylinder is $R = 7{\cdot}10\ \rho\nu d U$. The value of Ud/ν to which this formula applies is not to exceed 0·2.

"Production of Single Crystals of Aluminium and their Tensile Properties." By H. C. H. Carpenter, F.R.S., and Constance Elam.

An account is given of methods whereby small allotriomorphic crystals in aluminium sheets and bars have been converted into a single crystal. The parallel portion of the test pieces of the sheet was 4in. × 1in. × 0·125in. The conversion of this area into a single crystal involved three processes: (1) heat treatment for six hours at 550° C.; (2) application of tensile stress of 2·4 tons per square inch, producing an average elongation of 1·6 per cent on 3in.; and (3) a final heat treatment beginning at 450° and extending up to 600° C. The number of crystals present originally in the volume mentioned was about 1,687,000. Under above conditions, on an average one test piece in four produces a single crystal over its parallel portion, which frequently grows up into the shoulders of the test piece. This occupied a volume of about 0·5 cubic inch.

The tensile properties of the single crystals were determined. Considerable variations in the method of extension and fracture and the numerical values of the results were found. The tenacity of single crystals varied from 2·8 to 4·08 tons per square inch, while the extension on 3in. varied from 34 to 86 per cent. according to the orientation of crystal relative to stress. Differences in above properties have enabled specimens to be classified under five types. The results of the stress tests of test pieces consisting of two crystals and also of three crystals are given. These show the strengthening influence of one crystal upon another.

Later experiments conducted on round bars resulted in the production of single crystals in the parallel portion of bars 0·564 and 0·798in. in diameter. In the former case the total volume occupied by the crystal was rather more than 1 cubic inch, while in the latter it exceeded 2 cubic inches. The tensile properties of these crystals were also determined, and it was found that in every case a wedge-shaped fracture was produced, the bar diminishing principally in one dimension only. Remarkable twinning effects were observed in certain cases.

"Transmission Colours of Sulphur Suspensions." By C. V. Raman and B. Ray.

When a few drops of sulphuric acid are added to a dilute solution of sodium thiosulphate and a precipitate of sulphur gradually forms in the liquid, the light transmitted through the turbid medium undergoes remarkable changes in colour and intensity. The suspension becomes practically opaque to the shorter wave-lengths first and the longer wave-lengths later, and subsequently regains its transparency partially, the shorter wave-lengths re-appearing first and later the longer wave-lengths. In the present paper, the work of Keen and Porter and of Lord Rayleigh on the subject is discussed, and it is shown how the foregoing facts may be explained on a theoretical basis.

"Law of Distribution of Particles in Colloidal Solution." By E. F. Burton and Miss E. Bishop.

SOCIETY OF PUBLIC ANALYSTS.

Ordinary Meeting, November 2, 1921.

Held at the Chemical Society's Rooms, Burlington House.

Mr. Alfred Smetham, President in the Chair.

Certificates were read for the first time in favour of Messrs. Jack Cecil Drummond, D.Sc. (Lond.), F.I.C., Alfred William Long, John Charles Mellersh, Charles Harold Wright, M.A. (Cantab.), F.I.C.

The following were elected Members of the Society: Messrs. James Frederick Fothergill Rowlanad, B.A. (Cantab), A.I.C., William Norman Stokoe, B.Sc. (Lond.), A.I.C.

The following papers were read:—

"*The Testing of Foodstuffs for Vitamins.*" By J. C. DRUMMOND, D.Sc., F.I.C., and A. F. WATSON, B.Sc., A.I.C.

The authors suggested that sooner or later analysts must seriously consider the standardisation of methods for ascertaining the value of foodstuffs as sources of those unidentified dietary units—vitamins. They stated that there is already a big demand for information on the testing of food products, but unfortunately as yet the chemical nature of the vitamins is not sufficiently understood to enable chemical or physical methods of estimation to be employed, and for the present the biological method is necessarily utilised. The many sources of error in such a method were pointed out, particularly those caused by the variability of response in individual animals, and the influence of external factors; although the authors noted that these have been considerably reduced by recent improvements in technique.

Good equipment and organisation of the feeding laboratory and scrupulous care in preparing the "pure" foods for the basal diet were shown to be essential, and the practice in the authors' laboratory was described in detail, illustrated by lantern slides.

The authors then dealt with the testing of foodstuffs for the three recognised substances of the vitamin "class," and demonstrated the type of result obtained. In conclusion, they showed the value of the method in studying the seasonal variation in the food value of butters and milk, and discussed the significance of these new discoveries from the analyst's point of view.

"*An Improved Specific Gravity Apparatus.*" By C. BUTLER SAVORY, M.D., M.Ch.

The author demonstrated a new and efficient instrument for the determination of the specific gravities, which has a range from 0·2 to 1·9, and obtains direct results without calculation, to four decimal points.

CORRESPONDENCE.

ROYAL SOCIETY.

To the Editor of the Chemical News.

SIR,—You probably know that the Society possesses a collection of engravings and photographs of Fellows of considerable interest. The President and Council wish to continue the collection on the lines which have been adopted by the Trustees of the National Portrait Gallery, namely, by photographs uniform in size and character, which will be stored and catalogued; and arrangements have been made with Messrs. Russell & Sons, 73, Baker Street, W.1, by which they will take a photograph (by appointment) of any Fellow, free of charge, and deposit a copy with the Society.

The President and Council hope that those Fellows, who have not within the last two or three years given a sitting to Messrs. Russell, will assist in making the collection complete by arranging for a sitting as soon as possible.—We are, &c.,

W. B. HARDY,
J. H. JEANS,
Secretaries, R.S.

New Patents.

THIS List is specially compiled for the *Chemical News* by Messrs. Rayner & Co., Registered Patent Agents, of 5, Chancery Lane, London, W.C.2., from whom all information relating to Patents, Trade Marks and Designs can be obtained gratuitously.

Specifications published this Week.

170022—Seldon, J. M. and Seldon & Co.—Catalytic oxidation processes

149319—Linienfeld, L.—Process for the manufacture of compositions of matter and technical products containing ethers of carbohydrates having the empirical formula $n\ (C_6H_{10}O_5)$ their conversion products, and derivatives

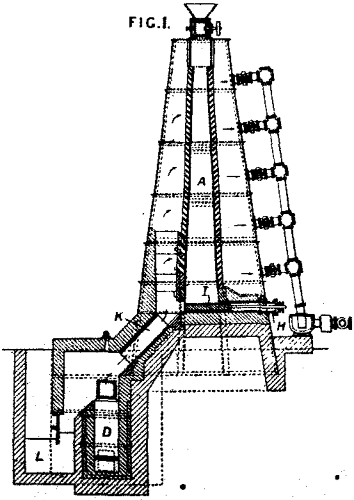
170056—British Dye-stuffs Corporation, Ltd., Green, A. G. and Herbert, A. E.—Manufacture of chlorinated derivatives of toluene

170155—Carpmael, W.—Manufacture of new soluble chromium lakes of azodyes

Abstract Published this Week

Gas Manufacture.—Patent No. 167822.—Some improvements in Gas manufacturing plants have been Patented by Mr. W. P. Perry, of 19, Lytton Road, Leytonstone, London, which are illustrated in the accompanying diagram. The carbonaceous material distilled in a chamber A by the pass age there-through of hot gases from a producer D is discharged down a sloping conduit K into the producer, any surplus fuel passing over the top of the fuel in the producer and into the chamber L from which it may be lifted by an endless screw. Two plungers I working alternately from a casing H may be used, the plungers filling the casing so that no fuel can enter the casing and interfere with their action.

FIG. 1.



Messrs. Rayner & Co., will obtain printed copies of the published specifications and will forward on post free for the official price of 1/- each.

MEETINGS FOR THE WEEK.

Wednesday, November 16.

Royal Society of Arts, 4.30. "Modern Buildings in Cambridge and their Architecture," by T. H. Lyon.

Society of Glass Technology, 2.30 (at Leeds). "Gas Reversing Valve for Regenerative Furnaces," by F. W. Knowles. Discussion on "The Melting of Glass."

Institution of Electrical Engineers, 6. "Telephone Line Work in the United States," by E. S. Byng.

Thursday, November 17.

Royal Society, 4.30. "The Design of Repeating Patterns" by Major P. A. MacMahon and W. P. D. MacMahon. "A Problem in the Theory of Heat Conduction" by Prof. J. W. Nicholson. "The Thermal Stresses in spherical Shells concentrically heated" by Prof. C. H. Lees. "Mathematical Foundations of Theoretical Statistics" by R. A. Fisher. "The Diffraction of Plane Electromagnetic Waves by a perfectly reflecting Sphere" by F. P. White. "On the Whispering Gallery Phenomenon" by C. V. Raman and G. A. Sutherland.

Chemical Society, 8. "The influence of nitro-groups on the reactivity of substituents in the benzene nucleus. Part V. Heteronucleal dinitro-derivatives" by H. Burton and J. Kenner. "Organo-derivatives of bismuth. Part V. The stability of halogen, cyano- and thiocyano-derivatives of teritiary aromatic bismuthines" by F. Challenger and J. F. Wilkinson. "Organo-derivatives of bismuth. Part VI. The preparation and properties of teritiary aromatic bismuthines and their interaction with organic and inorganic halogen compounds" by F. Challenger and L. R. Ridgway.

NOTICES.

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THE CHEMICAL SOCIETY RESEARCH FUND.

A MEETING of the Research Fund Committee will be held in December next. Applications for Grants, to be made on forms obtainable from the Assistant Secretary, Chemical Society, Burlington House, London, W.1.; must be received on or before Thursday, December 1st, 1921.

All persons who received Grants in December, 1920, or in December of any previous year, whose accounts have not been closed by the Council, are reminded that Reports must be returned by December 1st.

S. E. CARR, *Assistant Secretary.*

FOR Sale. *Journal of the Chemical Society* (unbound) for 1897, 1898 and 1899. *Journal of Society of Chemical Industry* (unbound) for 1900 and 1901. *Berichte der Deutsche Chemischen Gesellschaft* (unbound) from January 1897 to March 1899. Offers invited. F. F., 22, Newtown Street, Leicester.

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THE CHEMICAL NEWS.
VOL. CXXIII., No. 3214.

THE CHEMIST IN THE STEEL AND IRON INDUSTRY.

A FEW THOUGHTS ON HIS EXPERIENCES, TRAINING, STATUS, AND INFLUENCE ON MANUFACTURE.

By C. H. RIDSDALE.

(Concluded from p. 254)

THE *second* method—namely, of indicating the training—would appear good for the purpose in view, and no objection could be taken to it if every would-be candidate had an equal opportunity to undergo such training, but many, otherwise fitted, are so circumstanced through no fault of their own, that this is impossible. It seems hard on a youth earning his own living if he is ruled out, for instance, from a merely geographical reason, namely, that he lives too far from the nearest training centre.

I am *not criticising the Institute's arrangements* but merely looking at them from the candidate's point of view, and must admit that it is not much comfort to be told that :—

"The Council, having made provision for the admission of *all* suitable candidates to the membership, are *unable to concern themselves* with those who neglect the *many* opportunities afforded them for obtaining adequate training."—Editorial, *Proceedings*, Part V., October, 1920, p. 278.

The difficulties of special cases are no doubt recognised by many of the Fellows of the Institute, and endeavours are being made to extend facilities to meet them, and in the address of the retiring President, Sir James J. Dobbie (*Proceedings*, Part II., April, 1918, p. 40), with reference to some who decline to take the Institute's examination, and of whom, members who have passed it say : "Why should we trouble about those who decline? If they will not come in on the usual terms let them stay away. So much the worse for them." He says : "Unfortunately that is what *has* happened in the past. They have stayed away. We must face the fact that large numbers of highly-trained chemists decline to present themselves for our examinations." And later he says : "The fact is that the qualifications of many of them are quite up to the level of those which we demand of candidates for the Associateship." Meanwhile there can be no doubt that the Institute has done and is doing much to raise the status of chemists.

The British Association of Chemists—your own Association—also seeks to elevate the profession, if I understand rightly, in a somewhat similar manner to the Institute of Chemistry, but without holding examinations; some of you also, aiming at making the practice of analytical and industrial chemistry a close profession, and in addition to this to some extent employing trades union principles for increasing the payment of, and obtaining certain privileges for, your members.

The National Association of Industrial Chemists, I understand, makes still more distinctive use of these principles, regarding them as one of the most effective means of securing the welfare of the chemist, as interpreted by higher payment.

Reverting to the question of improving the status of chemists generally: we know there are two main methods which can be employed to bring this about, namely, technical and moral.

Technical.—(1) By rendering the chemist really more efficient and valuable, *e.g.*, by making his analyses of a regularly higher standard and degree of accuracy, and teaching him to apply his knowledge of chemistry, and the other characteristics of his training, to practical purposes.

Moral.—(2) By propaganda. (*a*) Demonstrating to and impressing upon people that he really is very valuable. (*b*) Implying or *asserting* that this is so, and as regards the members of certain societies, showing *as proof* of this, that they have passed certain examinations, obtained certain University degrees, or are possessed of certain qualifications considered equivalent. (3) By combination, &c., to force those employing chemists to pay them more.

As you will have seen from the brief description of the outstanding features of the societies, they seek to improve the chemist's status *technically* by making him study, and examining him, and *morally* by seeking to give him more *amour propre*, by propaganda, by using trades union principles for securing him better pay, and by the automatic exclusion of all who do not conform to their standard.

Now, whilst some of us may not approve of all the methods employed by these Societies, we must not forget that each of them is attacking part of the problem, and we should not criticise them severely on that account, or simply because the scheme does not cover the whole ground. Each society no doubt follows the course it thinks for the best, and I should like to see all taking a broader view and aiming rather less at benefiting their own members exclusively, and trying still more to advance Science, and to improve and elevate the profession as a *whole*. The greater the status which any society wishes its *members to hold, the more important* is it that it should be conducted on high principles. Further, if they were all pulling together and working in concert for a common aim, more advance would be made. As it is, there is some overlapping and some gaps occur. A good deal has, however, already been done towards this, such, for instance, as the preparation of Abstracts by the Chemical Society and Society of Chemical Industry in conjunction.

I have sometimes been asked : "If I join such and such a society will it do me any good?" So far as a works' chemist is concerned, frankly I do not think that his being a member of some Society or being able to put certain letters after his name will have much effect in the matter of pay with most managers; at any rate, it is no use depending on it. The benefit is largely reflex, in making him try to be worthy of its traditions, attend its meetings, follow the papers and discussions, study its proceedings, and especially himself preparing a paper for it. In short, he gets most who gives most.

Now it is well known that if we would improve anything we must lay bare its weaknesses and

*An address given to the Glasgow Branch of the British Association of Chemists, October 10, 1921.

study how they may be removed, and this applies equally to the chemist.

As regards technical matters, I have long felt that there was nothing which had such a prejudicial effect on the status accorded to chemists by laymen as the occasional disagreements between their analytical results.

In fact, you will meet people from time to time who will tell you "chemists are no good," and proceed to quote some glaring example of two chemists of standing finding distinctly different results. And although most of the serious differences if investigated prove to be due to variations in sample, yet we know some methods are far from perfect, and that there is sufficient ground for complaint from the commercial man's point of view to make it imperative for the chemist to look into this matter and use every means for improvement

As far back as 1894, Mr E. Windsor Richards thought this matter of such importance as to bring it before the Iron and Steel Institute in his Presidential address, and said: "Very considerable trouble and expense have been experienced by manufacturers through differences in analysis by different chemists." Later, before the same Institute, in a paper by my son and myself, we referred to this and pointed out that figures specified should not have uncertain values, and that a figure such as, say, 0·07 per cent phosphorus depended entirely on the personality of the reference chemist; if he found a high result this might limit the steel maker actually to 0·055 per cent, or, on the other hand, allow him up to 0·08 per cent.

This state of things gives rise to distrust, and undervaluation of the ability of the chemist. The layman does not know the limits of usual accuracy of methods, and particularly of methods worked hurriedly. Thus, whilst on the one hand he presses the works chemist, for the utmost speed, he blames him as unreliable if the reference chemist's result turns out differently.

For, in such cases it is generally the works' chemist who is believed to be wrong. Many years ago this fact was brought home to me, and I, like many others, felt it deeply.

I have often, during my career as a works' chemist, felt the singular appropriateness of Rudyard Kipling's lines:—

"The Toad beneath the harrow knows
Exactly where each point prick goes
The Butterfly upon the Road
Preaches contentment to the Toad."

You can guess who the butterfly is.

Hence regular agreement between chemists on what purports to be the same sample is a *sine quâ non* if as a body their status is to be upheld.

Next to the limits of accuracy of methods, the greatest obstacle to regular agreement is professional pride. You know the old saying, "doctors differ," and how No. 2 smiles when you tell him what No. 1 said, and conveys the feeling, "what else could you expect if you went to him?"

There is a good deal of this about chemists too; not only chemists in private practice, but in some works' chemists also, and people of this turn of mind adopt the attitude: "The methods I have selected, and the way I work them give right results, and I don't propose submitting them to any test which might show, or appear to show them to be wrong."

I understand that one well-known institution used for reference refuses, in cases of differences, either to let chemists work side by side with them, or to return part of the samples

In such circumstances, therefore, the works' chemist, though he may feel convinced he is right, is, or was until recently, in a hopeless and very uncomfortable position.

As early as 1886, I felt this strongly, and commenced to write a paper entitled "Works' Chemists and Analyses," dealing with the subject. I never finished it because I realised our hands were tied. What we needed was some means which could be used in any particular case to *prove* who was right, and until we had that, merely to assert that we were right would be futile. From that day to this my interest in the works' chemist and his difficulties never weakened, but became stronger.

I may perhaps be permitted briefly to refer to two ways in which during the last few years endeavour has been made to meet these difficulties.

The first has in view particularly, enabling hard-driven junior assistants who have to make certain tests of the same kind, time after time, to do this easily with accuracy and more quickly. By standardising the methods in question, making their chemical principles clear, and ensuring their exact observance, variable factors and drudgery are largely removed, and the assistants have a better opportunity to improve their knowledge both of those and of further methods.

This system, and also some of the methods, have been described in various papers, one of them by your fellow-citizen, Mr. Herdsman.

The second had for its object proving who was right in case of disputes by affording some means for gauging the accuracy of the work of the analysts who differed. I am sure you all understand that if in such a case, for instance, a sample of unknown composition is run through side by side with a uniform sample the composition of which is accurately known, and the latter gives the correct result, then the probability that there is any error in the testing of the unknown is very small.

If a representative selection of makers, users, and independent chemists have jointly standardised these samples, and will on this account, and because of their wide acceptance and use, acknowledge them, the rest is simple.

This is just what has taken place owing to the co-operation of a large number of such chemists, and to-day there is a range of plain carbon and alloy steels and cast iron, comprising 78 standardised results for elements, available and in use in the British Isles and other countries; this type of method used for determining each element, and the result found by each co-operator who has tested it, being shown in a certificate issued with it.

But apart from technical improvement there are other ways in which chemists can improve their status. They must, of course, have sufficient chemical knowledge to fill their own position—and preferably a good deal more—but that alone is not sufficient. Every manager knows there are qualities of greater value than the purely technical knowledge of one's own business. We have had many examples, especially of recent years,

of men being offered controlling interests in businesses of which they had little or no technical knowledge—and proving successful too—simply because they had organising ability, or some other quality which outweighed what they lacked.

The same principle applies to lesser things, and conversely a young chemist who has considerable technical ability may neutralise the value of this in his employer's eyes by some fault or deficiency of a quite ordinary nature. Let us follow this thought for a moment.

You all know that an analysis which is not accurate is worse than none, because it is misleading; it purports to give certain information, and that information is incorrect. And accuracy depends on carrying out the method which is capable of giving correct results with absolute precision in every detail.

To the chemist the two most valuable assets—essentials in fact—are precision and integrity. The first demands the second. Precision is integrity in little detail. Apart from our recent labour troubles, one thing our industries, and indeed, progress generally, are suffering from, is want of precision You can trace it in almost everything. For economy and progress in manufacture we need a closer approach to the conditions of the laboratory; finer working and greater regularity all through.

In an address to the Cleveland Institution of Engineers, 1907, I traced how this hindered the iron and steel industry, and have repeatedly referred to the same facts in discussion. In short, the national, and indeed world-wide canker, the spirit of the age, is a revolt against precision and painstaking in all the so-called little things of life.

Now the reason I venture to mention this point to you is, that no class of men better understands the truth of what I say than chemists, and it is easy to see how useful the chemist can be to manufacture, when permitted to control it, not for his chemistry alone, but by his influence, the introduction into it of precision, orderly and systematic working, and exactitude in detail.

Indeed, this influence may extend for beyond manufacture, and imbue the world around him with the same spirit. It is largely through the example and influence of chemists that we may hope to counteract the plausible, and on that account all the more injurious tendency which—as many thinking men realise—has spread during the last generation through almost all circles, viz., the tendency to lax and slovenly ways, inattention, and forgetfulness. The war unfortunately gave a certain amount of excuse for general slackness, and the public were not slow to avail themselves of it to the full.

Those who try to fight it down are generally regarded as being unreasonable, and expecting too much: "anybody may forget," they say"; "you can't expect old heads on young shoulders," and so on.

People can understand the seriousness of the slightest laxity when it is a question of giving the wrong tablet on a single line railway, or smuggling matches into a fiery mine or explosive factory. Yet the same holds good for nearly everything in life, and is fatal to many young people's progress.

Laxity is really a form of selfishness, for he who yields to it, in order to save himself an infinitesimal amount of trouble, may cause a disproportionate amount to fall on someone else. On similar lines, one department of a works, to save itself a little extra trouble and a few coppers may cause another department to lose several shillings.

Arising out of this, it would be well if every chemist who wants to get on—and every employee for that matter—would keep in mind that a manager's time is more valuable than his own, and not a minute of it should be wasted through any fault of his.

The manager's function is largely creative; he has to think out schemes for progress of the concern. Continual little wastes of his time, whether through technical matters or such things as I have named, effectively hinder him. Naturally, therefore, he values those most who use forethought and attention, and on whom he can rely.

Anyone who has studied the run of an express train (such as is sometimes given in *The Engineer*) will be struck by the serious reduction on the "all-over" speed per hour of a succession of short stoppages, and how these mount up.

Why do so many who give addresses drift into similar non-technical questions? Simply because they who give them realise the important bearing which these have, not only on our industrial life, but our general well-being.

Let us now look very briefly at several successive stages of a chemist's career, and how he may seek throughout it to improve his status. I need say very little as to what is desirable as regards the purely chemical part of it, as this for each branch will be shown him by his chief. If he is able to enter the profession with the training and along the lines recommended by the Institute of Chemistry, this will have been well looked after. If he has not had these opportunities, but, as so many young men have done, has gone straight into a *works' laboratory* with only an ordinary school training, obviously he must try all the harder by attending technical classes, and studying some of the excellent text-books, of which there are so many, to make good his deficiency. But he must *not* rely on the chief chemist to teach him general chemistry, for this hard-worked official usually has far too many duties for him to be able to do more than instruct him as to the matters of the particular laboratory, and at most give him, if applied to, some general indications and advice. But whatever the beginner's chemical education, and the steps he has taken to improve it, there are many things he can do to improve himself and make himself valued.

He should keep always before him that he has entered a *profession*, and by intelligent and conscientious work try to live up to the dignity of it. I have already referred to the advantage of joining one or more chemical or technical societies, and to the importance of paying very close attention to instructions given him Hence, when receiving them, he should remember that it is *his* business to make sure he understands them correctly, not the employer's to hammer them into him. He should at once make notes of what he is told. He must concentrate first on learning his own work as perfectly as possible. He must also keep his eyes and ears open to learn and understand as much as he can of the processes that are

going on around him. He must get a clear conception exactly for what object any given analysis is made, what informarion is wanted, what it really shows, and how its significance is to be most clearly conveyed and interpreted to non-chemists. He should also consider what analyses should be made to cast light on some particular works' problem. The more advanced his position, the more necessary these things are. He should study deductive reasoning, but when practising this, be very careful to keep himself unbiassed. He must not try to make facts fit what he wants to prove or he will hoodwink himself. Then, when he has done this, he should try and be an understudy to the man above him.

As he becomes more experienced he should try to look at these things as though he were in the chief chemist's place, and think what course he would take if it devolved on him to carry out the work and investigations.

If he reads collateral technical literature, such for instance as metallurgical and engineering newspapers, it helps to broaden his mind, and show him some of the problems and points of view of other workers.

The chief chemist in turn should mentally put himself in the works' or general manager's place, and ask himself what he would do if he were really in that position? Perhaps when he comes to think it out seriously, he finds he has not got quite so many easy solutions to the various problems as he may have thought when he was simply criticising their action.

To do as I have indicated tends to increase the sympathy and appreciation of each man for the one above him, and enables him to give more willing and effective service.

So too, if he is aiming at commencing a public practice of his own, he must picture himself in that position, where he has to stand alone far more than in a works, and where he cannot afford to make mistakes at all.

For, the chemist in public practice depends entirely on his *reputation*, which means that there is expected of him practical infallibility in analysis. Hence, any carelessness in him or his staff, if not detected, would be fatal. I need not, however, say more about him beyond this, as he is outside the scope of my remarks.

As regards the works chemist, my own feeling is that the works' laboratory is the finest possible field for a volunrary hard worker, and since the test in real life is not what a man knows but what he achieves, as a training ground it develops ability and resource to an extent which academical training alone cannot, the very difficulties bringing out a man's better qualities.

I should like to see this taken more into account by those who from time to time attempt to gauge a works' chemist's fitness for admission to some society, or in any way confer honours, and with whom at present the qualifications of theoretical knowledge still appear to weigh most.

Now I wonder whether I dare say anything to you on so delicate a subject as the use of combination and trades union principles or methods by works chemists for improvemenr of their financial status?

If I understand rightly, your Association has—reluctantly and through the inelasticity of the law—as a matter of form registered as a trades union for special reasons apart from the general principles, and the majority of you do not wish to follow these.

I know, however, that the idea does rather appeal to many young chemists in works who see other youths, who do considerably less skilled work, earning more money. That is why I will venture to submit one or two thoughts on it for your consideration.

I mentioned earlier, that the balance and correct sense of proportion acquired from the nature of their business enabled chemists to deal safely with forces otherwise dangerous. So, combination used as a weapon to enforce some concession needs to be employed with great care; and with knowledge and realisation of its full effects, direct and reflex, or it may defeat the object for which it was employed, or have disastrous effects in an unlooked-for direction.

It would appear that your Association is handling it with great care, but many workers have experienced its dangerous side, and I fancy ideas will be modified a good deal in the near future.

Chemists, as some of the principal thinkers of the world, should be *leaders*, not *led*, and although I certainly want to see chemists more highly valued and better paid, I doubt whether this method is so suited to their case, and though it may succeed as regards payment, especially for juniors, it will be harmful in other respects.

It seems to me rather an admission of a weak position and of individual inability to rise above the average. Then, any sort of standard payment (such as combination secures for a class), always depends on *averaging*, which for many individuals means levelling *down*, rather than levelling up.

The wholesale regulation of wages may be desirable for *masses* of relatively uneducated men doing work of a uniform and comparatively low mechanical type, but the chemist should be doing work which constantly requires more and more ability. Hence he particularly should not be bound by anything that checks the advancement of the individual, as he improves.

But the greatest objection to this use of combination is, to my mind, that its results are usually directly contrary to the spirit which animates the true chemist, namely, the pride in good work, which it is su desirable should spread through the world, and towards which his example and influence is so much needed.

In the early stages there was the pride of the craftsman, each man striving to excel in his own vocation. Now the whole tendency seems to be to hinder men from doing better work than their fellows, and to grind them down to a common level.

By all means strive to improve your financial position and material welfare, but do not adopt methods which will reacr to your disadvantage. In your effort for this, depend chiefly on the making of yourselves better, more able, and of such worth that men *must* have your services; and get the satisfaction of your increasing capability, and in the feeling that you have done good work.

Perhaps you think I am saying far too much about the moral aspect. I have done so because I believe that it is chiefly the moral qualities

which bring a man success and give him happiness, and it is these alone which will bring about a better state of things in the world between employer and employee, and in all the relations of life. Can any of you tell me of a better or more powerful means?

I have used the word "moral" in its widest sense, but I think you will agree that what may really be called moral qualities in the secular sense, such as diligence, perseverance, &c., are the outcome of the deeper, more spiritual quality. I have already referred to the fact that the necessity of recognising these things as vital factors in business affairs is being acknowledged more and more of late by hard-headed practical men, and want to read you a few words, *not* out of a parish magazine by a clergyman, but out of a very able paper before the Royal Society of Arts, which you will find in the *I. & C. Trades Review* (February 28, 1910, p. 263), by the Chairman of Messrs. Cammell Laird's, Mr. W. L. Hichens, on "The Wage Problem in Industry." In concluding, he says: "Ultimately all industrial questions as well as all other questions affecting human relations resolve themselves into moral problems, and how far we succeed in solving these questions depends on the degree of moral consciousness . . . The words 'Seek ye first the Kingdom of God, and all these things shall be added unto you,' have become a commonplace of literature, and are probably endorsed in church on Sundays by innumerable congregations as sound doctrine, but inapplicable to the affairs of every day business." Once back in the workaday world, common sense prompts us to murmur:—

> "Ah, take the cash and let the credit go,
> Nor heed the rumble of the distant drum......"

But is it really common sense?

The Presidential address to the Economics Section (F) of the British Association given by the same author and published in the September 16, *1921, number of the same journal, pp. 305-6, also* very ably deals with the same problem.

Unless men with the knowledge and balance of chemists will believe and act on these principles in their lives, how can we expect workmen or others to do it?

Until the employee, and in fact, every one who has a commodity to sell, whether it be goods, brains, or manual labour, learns that his self-esteem demands that he should be as much concerned to *give* good value as to *receive* it, we shall never have a really satisfactory state of affairs.

I feel sure you will have gathered from what I have said that both for happiness and for success in business one must have the driving force of a *definite ideal*.

A man may be a good chemist technically, and yet not achieve much for want of this.

On the other hand, there are men who show no moral aspirations, and will tread on anyone's shoulders to get on rapidly. They don't get on *because* of their objectionable qualities, but in spite of them, because they have an ideal, albeit a low one, and are always working towards it. Hence, though they show no concern for others, they study their employers, anticipate their wishes, and make themselves as useful as they can to them.

Now a few final words, especially to the younger men. Don't waste time thinking over the injustices you have suffered. Everyone suffers lots of injustice and hindrances in their attempt to get on. If blamed, consider carefully whether there is not really some justification. Then you will extract any good there is to be got out of it.

Don't exaggerate the idea of your own value, but make sure that you really are valuable.

Don't be discouraged if success seems a long time coming.

Fix on a strong, clearly defined ideal, and "think high." *If your ideal is low you will* achieve a low standard. Then *have confidence* in yourself, and don't be afraid to follow wherever it leads you.

You will then probably find your present position offers, or can be made to offer, wider opportunities of advancement. If you are quite sure you can't achieve it in that position, then leave it, and if you really have the value you think, you are bound to get a better—you can't sink.

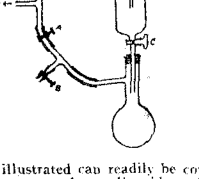
I cannot do better than conclude with two verses from Ella Wheeler Wilcox's "Limitless":

> "When the motive is right and the will is strong
> There *are* no limits to human power;
> For that great force back of us moves along
> And takes us with it in trial's hour.
>
> "And whatever the height you yearn to climb,
> Though it never was trod by the foot of man,
> And no matter how steep—I say you *CAN*,
> If you will be patient—and use your time."

A SIMPLE RECEIVER FOR FRACTIONAL DISTILLATION UNDER *DIMINISHED PRESSURE*.

By E. J. WILLIAMS.

THE subjoined sketch illustrates a receiver, working on the principle of that of Lothar Meyer, for fractional distillation under reduced pressure. The receiver of Lothar Meyer has not hitherto *been manufactured by any English firm. It is* rather a fragile piece of apparatus, and the form at present exported from Germany (with a ground glass joint) requires firm handling whilst changing the receiver.



The form illustrated can readily be constructed in the laboratory. A small wide-necked tap-funnel is fitted with a two-holed stopper. Through one hole passes an adapter into which the condenser tube leads. A tube through the other hole is connected with a T-piece, one arm of which leads to the manometer and pump. The receiver proper is a small distillation flask to whose side

tube is connected a second T-piece joined up as sketched, A and B being screw-clips.

To change the receiver C and A are closed, then B is opened, when the small distillation flask may be disconnected and replaced by another without interrupting distillation. B is then closed and A opened followed by C.

The clips A and B, with their connecting T-piece, may, of course, be replaced by a three-way tap, which may be made in one with the upper T-piece.

Royal Grammar School,
Newcastle-on-Tyne.

THE AIMS AND BOUNDARIES OF PHYSIOLOGY.*

By Sir WALTER M. FLETCHER, K.B.E., M.D. Sc.D., F.R.S.

Upon the occasion of our meeting in this metropolitan city of Edinburgh, the seat of an ancient university and a great centre of medical study and practice, it has occurred to me that it may be profitable for us to consider the part which physiology should rightly take in its relation to national life, to learning, and to medicine. Not only the place of our meeting, indeed, but some special circumstances of the present time seem to make it fitting that we should here review the progress, the proper scope, and the prospects of our chosen subject. We are now just half-a-century from the time when physiology first came to take its present position in this kingdom as one of the great branches of university learning and as a vital branch of medical education. We have seen the close of a war which, though it diverted and distorted the progress of the science, yet brought it great opportunities of service in national life and taught us lessons, here as in so many other directions, of which we shall do well to take profit. The passing of the War, moreover, has brought a period of change and unrest during which impulses towards reform are being chequered by the results of fatigue or reaction. Both here and in America it may be said that, while physiology has come from the war with enlarged outlook and responsibilities, it is exposed to some new and perhaps dangerous influences in the present time of rapid resettlement. It may be worth while, then, to look now both forward and back, to see the road by which we have hitherto been led and its relations to that which now lies before us.

I.

Physiology, as the passing generation has known it, took shape and established its boundaries in this country just fifty years ago, when, shaking off its long subordination to anatomy, it was brought to a new life of recognition and progress. The seventeenth century had seen England famous for her schools of physiologists, leading the rest of the Continent in experimental results and in new ideas. Working upon the foundations laid by Harvey, that brilliant group at Oxford—Boyle, Lower, Mayow, Willis—had brought new light to the study of the living body. Nor was their service only recognised by fellow-workers abroad or by those that came after. Their names and fame were on fashionable lips; like that of their predecessor Harvey himself, under Charles I., and of that other Cambridge philosopher Glisson, their immediate contemporary, their work was aided by the direct interest and favour of the sovereign. But, during the eighteenth century and the earlier part of the nineteenth, eclipse fell upon the light that had thus burned so brightly, though isolated gleams shone here and there. James Jurin, under George II., applied the Newtonian principles to calculating the work done by the heart and to other problems of the body, but his efforts to lay true and exact foundations for the study of disease were premature in the absence of experimental data. Stephen Hales, Chaplain to the future George III., made the first measurements of blood pressure in his garden at Teddington, and made many far-reaching observations of the first importance; but, as he wrote, there was indeed "abundant room for many heads and hands to be employed in the work, for the wonderful and secret operations of Nature are so involved and intricate, so far out of the reach of our senses . . ."; and it was not then or till much later that many heads and hands were ready to be employed. Neither of these men had effective influence upon the thought or practical affairs of their day, either within the universities or outside them.

Physiology, as we know it now in this country, took its shape in a new revival which may be reckoned as beginning half-a-century ago. All our chief schools may be said to derive their lineage from that new home of active and unshackled inquiry—I mean University College, in Gower Street, London—and from the influence there of an Edinburgh graduate, William Sharpey, who at the age of thirty-four was taken from the Edinburgh school to be Professor of Anatomy and Physiology. Here, from 1836 until 1874, Sharpey was inspiring a group of younger minds with his eager outlook. Already in France the new experimental study of the living functions was being established by Claude Bernard—that true "father in our common science," as Foster later called him; already in Leipzig Ludwig, transmitting the impulse of Müller's earlier labours, had founded that school of physiology which moulded the development of the subject in Germany and other countries, and had very strong early influence upon several of those who were later to become leaders with us. England had lost the pre-eminence that Stuart kings at all events had valued and promoted. Learning had become identified in English society with the mimetic use of the dead languages, and progress at the two universities—even at the Cambridge of Newton, where mathematics kept independence of thought alive—was still impeded by the grip of ecclesiastical tradition and by sectarian privilege. But at University College learning had been unfettered. Here Sharpey and his colleagues were in touch with the best progress in France and Germany, and here the organised study of physiology as a true branch of university study may be said to have begun. Its formal separation from anatomy came later and irregularly; a separate Chair of Physiology was not created at University College until 1874, nor at Cambridge or at Oxford until 1883.

We ought in piety to recognise that this tardy reflection of Continental progress in our own sub-

* Address delivered before Section I, British Association (Edinburgh Meeting).

ject, like parallel movements in other subjects, had in its early stages received invaluable aid from the Prince Consort, who, familiar with the progress of other countries, had lent his influence and sympathy to many men of science in their struggle against the insularity and apathy of the wealthy and governing classes of the earlier Victorian days. The curious may take note that the first outward mark of recognition given by the official and influential world to the existence of physiology as such was given not, as in other and poorer countries much earlier, by the endowment of some chair or institute for research and teaching, but by an act of symbolic representation. For, when the expensive statuary of the Albert Memorial was completed in 1871, it was found that "Physiology," betokened by a female figure with a microscope, had been given its place among the primary divisions of learning and investigation acknowledged in that monument to the Prince.

From Sharpey himself and his personal influence we may trace directly onwards the development of all the chief British schools of physiology whose achievements have in the past half-century restored Britain to more than her old pride of place in this form of service to mankind. We here fittingly acknowledge first the close link with Sharpey which we find here to-day in Sir Edward Sharpey Schafer, who, after fruitful years in his old teacher's place at University College, brought that personal tradition back to this great school of Edinburgh from whence it originally came. At University College itself the line has been continued with undimmed lustre by Starling and Bayliss and their colleagues to the present day. From Sharpey's school again are derived the great branches which have sprung from it, both at Oxford and at Cambridge. Burdon Sanderson, Sharpey's immediate successor at University College, proceeded thence to Oxford and founded there, against many difficulties of prejudice and custom, the school of physiology which Gotch, Haldane, and Sherrington have nevertheless maintained so brilliantly in succeeding years. To Cambridge, Michael Foster, one of Sharpey's demonstrators, was invited in 1870 by Trinity College to be Praelector in Physiology and Fellow of the College. This enlightened and then almost unprecedented act, no less than the personal qualities of Foster that so aboundingly justified it, I would, as in private duty bound, hold here in special remembrance. Under Foster's influence there came into being at Cambridge a strong and rapidly growing school of physiologists, from Langley, Gaskell, Sherrington, Hopkins, to numerous successors. There sprang from him, too, a new impetus to other subjects, through his pupils Francis Balfour and Adam Sedgwick to embryology and zoology, through Vines and Francis Darwin to botany, through Roy to pathology. From Foster again through Newell Martin, who, coming with him from London, had caught not only inspiration from him but some of his power of inspiring others, and who left Cambridge for a Chair at Baltimore in 1876, we may derive a large part of the growth and direction of physiology since that time in the United States and in Canada. The rapid progress of all these biological sciences at Cambridge within a single generation, and the volume of original work poured forth depended, of course, upon two necessary conditions. The first is one which has never failed in this country —the existence of men fitted by temperament to advance knowledge by experiment. The second has been the supply of living necessities through the ancient endowments of the colleges, and these in the Cambridge of the last half-century have been freely and increasingly used in catholic spirit for the increase of any of the borders of knowledge.

If these have been the chief lines of descent along which our present heritage has come to us, as mind has influenced mind and the light has been passed from hand to hand, what has been the outcome as we look back over the half-century to those small beginnings?

Truly we can say that the workers in this country have in that short space of years laid the whole world under a heavy debt. In whatever direction we look we seem to see that in nearly all the great primary fields of physiological knowledge the root ideas from which further growth is now springing are in great part British in origin, and based upon the work of British experimenters. If we consider the blood circulation we find that our essential ideas of the nature of the heart-beat were established by Gaskell, and that other first principles of its dynamics and of its regulation have been laid down by successors to him still with us; that the intricate nervous regulation of the arterial system has had its chief analyses here, and that here have been made more recently the first demonstrations of the part played by the minute capillary vessels in the regulation of the distribution and composition of the blood. Of the central nervous system the modern conceptions of function in terms of the purposive integration of diverse impulses along determined paths have sprung direct from British work, while the elementary analysis of the structure and functions of the sympathetic nervous systems has been almost wholly British in idea and detail. As with the nervous regulation of the body, so with the chemical regulation of function by travelling substances—the so-called "hormones," or stimulants from organ to organ—this, too, is a British conception enriched by numerous examples drawn from experimental work in this country. In the study of nutrition, of the primary "foodstuffs," proteins, carbohydrates, fats, salts, and water, whose names in their supposedly secure sufficiency were written with his own hand by Foster upon the blackboard shown in his portrait by Mr. John Collier, to typify, as we may imagine, a basal physiological truth, we have come to learn that these alone are not sufficient for growth and life in the absence of minimal amounts of accessory unknown and unstable substances, the so-called "vitamins," which are derived from pre-existent living matter. This conception, undreamt of to the end of the nineteenth century, has fundamental value in medicine and in agriculture, and has already begun to bear a harvest of practical fruit of which the end cannot be seen or the beneficence measured. This discovery stands to our national credit, and large parts of its development and application have been due to recent British work. If we turn to the regulation of

respiration and its close adaptation to body needs, that also, as it is now known to the world, is known as British labours have revealed it, just as the finer analyses of the exchanges of gas between the air and the blood and between the blood and the body substance have been made with us. The actual modes by which oxygen is used by the tissues of the body, its special relations to muscular contraction, the chemical results of that contraction, the thermal laws which it obeys—all these fundamental problems of living matter have seen the most significant steps to their solution taken within the past generation in this country.

Work of this kind brings permanent enrichment to the intellectual life of mankind by giving new and fuller conceptions to the nature of the living organism. That we may think is its highest function; but it does more than this. Just as all gains in the knowledge of Nature bring increase of power, so these discoveries of the past fifty years have their place in the fixed foundations upon which alone the science and the arts of medicine now or in the future can be securely based. The special study of disease, its cure and prevention, has had notable triumphs here and elsewhere in the same half-century, and these as they come make as a rule a more spectacular appeal to the onlooker. Yet it is the accumulating knowledge of the basal laws of life and of the living organism to which alone we can look for the sure establishment either of the study of disease or of the applied sciences of medicine. As we have seen, *there are few indeed among the fields of inquiry* in the whole range of physiology in which the British contributions to the common stock of ascertained knowledge or of fertile idea do not take a foremost place. It would be impiety not to honour, as it would be stupidity to ignore, these plain facts, which, indeed, are now perhaps more commonly admitted abroad than recognised at home. There is no occasion here for any spirit of national complacency—rather the reverse, indeed. British workers at no time earlier than the War have had the menial assistance or other resources which their colleagues in other countries have commonly commanded, and too often the secondary and relatively easy developments of pioneer work done in this country have fallen to well-equipped and well-served workers elsewhere. If in the past half-century better support had been available from public or private sources, or at the older universities from college endowments, it is impossible for any well-informed person to doubt that a more extended, if not a more diversified, harvest would have been won.

We stand too near to this remarkable epoch of progress to appraise it fairly. In the same span of years Nature has yielded many fresh secrets in the physical world under cross-examination by new devices which have themselves been lately won by patient waiting upon her. So great a revelation of physical truth has been lately made in this country, bringing conceptions of space and of matter so swiftly changing and extending, that our eyes are easily dimmed to the wonders of that other new world being unfolded to us in the exploration of the living organism. Only the lapse of time can resolve the true values of this or that direction of inquiry, if indeed there be any true calculus of "value" here at all. We seem to see in the progress of physiology, not at few but at many points, that we stand upon new paths just opening before us, which must certainly—as it seems—lead quickly to new light, to fuller vision, and to other paths beyond. The advances of the next half-century to come must far exceed and outshine those due to the efforts of the half-century just closing; that is probably the personal conviction of us all. Yet we may still believe that through all the history of mankind recognition will be given and honour be paid to the steps in knowledge which were made first and made securely in the period we now review. The men who have done this work will not take pride in it for themselves; they know that their strength has not been their own, but that of the beauty which attracted them, and of the discipline which they obeyed. They count themselves happy to have found their favoured path. Other and more acute minds might have usurped their places and found greater happiness for themselves if, under a social ordering of another kind, they had been turned to the increase of knowledge instead of to the ephemeral, barren, or insoluble problems of convention and competition. By how much the realised progress towards truth and the power brought by truth might have been increased under a changed social organisation we can never know, nor can we guess what acceleration the future may bring to it if more of the best minds are set free within the State for work of this highest kind, what riches may be added to intellectual life, or *what fuller service may be given to the practical* affairs of man and to the merciful work of medicine.

II.

To the story of progress which has just been sketched in outline the War brought inevitable interruption and change. To the more obvious disturbances and wastage of war I need not here refer, but I would point to some influences of that time which will be found, I think, to have left permanent effects, and on the whole good effects, upon the position and tendencies of physiology. Before 1914 physiology was being developed, as we have seen, in its still youthful status as one of the primary departments of knowledge; it had become a subject of independent university rank Large and important parts of this development had proceeded at one or other of the ancient universities, out of touch with great centres of population, and out of touch, therefore, with immediate medical needs. In some degree this was not without advantage, and for two main reasons. Detachment from the pressure of need allowed the free pursuit of knowledge for its own sake and a full surrender to the hintings of Nature, wherever her clues might lead the inquirer. Experience amply showed, moreover, that when physiology was presented among other university subjects for study it gained, first as recruits and later as distinguished workers, many able young men who were attracted to it, often from other subjects, by the fascinations of its problems, and without regard to any of its potential applications to medical or any other practical ends. These were great gains which it would he easy, if it were not unnecessary, to illustrate by many convincing examples. Yet there were some heavy counterweights on the other side of the balance. The practical and urgent needs of humanity as found

at the hospitals were not brought with full or due effect to the notice of physiologists. Those in charge of hospital patients were not selected to advance, or habitually engaged in advancing, medical knowledge, and new physiological conceptions as they took shape in our laboratories only slowly and partially came to have effect in medical practice and medical study. The physiologist, to his own certain loss and to the no less certain loss of medicine, held aloof from the bedside, often when access was possible, and remained immersed in his laboratory interests. Little pressure, indeed, was ever brought to bear upon him by the physician to come to his aid. Connected with the evils of this separation was the divorce which the accidents of development had set up between physiology and pathology, as though the study of the damaged body could be separated from the science of the living organism and of its reactions to any disturbance from the normal. Yet, while the physician had come to tolerate the approach of the pathologist to the bedside, it occurred too rarely that he felt the need of the physiologist, or made himself familiar with new devices of physiological investigation.

If from a hospital in time of peace the most obvious call had seemed in the past to come from the side of infective disease or morbid process for the help of the pathologist, in war the stresses put upon the healthy human body made the physiologist and his methods indispensable. Bacteriological work and studies of immunity had their prominent place, of course, in the detection and prevention of infective disease, and wonderful were many of the achievements seen under this head. But in a sense the more complete the prevention of infective disease the more apparent became the physical stresses of war. The violences offered in modern warfare to the human body—whether through exertion and exposure, by terror or excitement, in physical damage by lead or steel or in chemical attacks by poison, and not least through the incredible stress of flying high and fighting in the air—all these brought many new and urgent calls for precise physiological knowledge and for new studies by the physiologist. The results of pain and fear, of hæmorrhage, of "shock" by wound or operation—all these needed further analysis before sound treatment could be devised or improved. New studies were needed of changes in blood-pressure and blood-volume and in the qualities of the blood itself, new inquiries into the finer vessels of blood circulation and their relation to the nervous and other systems, and new analyses of the chemical mechanisms of the body and of the modes by which want of oxygen is met by adaptation or leads to final damage. But the well-nigh incredible demands made upon the machinery of man's body in and behind the battle-line, in all situations upon the land or under the earth, high in the upper air, in the sea or within its depths, by no means make up the tale. Our forces were engaged in every climate, from the Equator to the Arctic regions, and were faced by innumerable local or accidental variations of diet. Here again were required the applications of physiological studies of heat loss and of heat production to manifold practical problems of clothing and of diet. What would have seemed a fanciful tale barely 20 years ago might in particular be told of the miracles wrought by the studied application of our new knowledge of "vitamins" in diet, in saving from painful disease or death many thousands of men in diverse climates and fields of war.

At home the bodies of the civilian population were exposed to many stresses, often hardly less than those of active service. Men and women alike were exposed to arduous toil, to dangerous occupation, to poisons of many kinds needed for munitions, and in all of these dangers the guidance of the physiologist was needed for the avoidance of industrial fatigue and loss of output and for devising protection against industrial poisoning. The whole nation was threatened by the menace of starvation, and our escape from that, itself one of the governing conditions of our ultimate victory, was due to a system of rationing and of the management of food materials, animal and vegetable, which was based on accurate physiological knowledge, won by experimental methods.

I touch on these points here briefly and in outline only in order to draw attention to the special influence which, I think, the War has exercised upon the position of physiology in this country. The physiologists gave no exceptional help to the nation during the War; the exponents of every branch of science were needed, were ready, and were used, in our national crisis. Hardly one division of science can be named the deficiency of which would not have made defeat inevitable. It is a truism and a commonplace to say that without the help of scientific men and of the fruits of experimental science, though that commonplace has not, I think, ever yet been enshrined in the addresses or thanks of Parliament or in the prayers and thanksgivings of our churches. But we may recognise, perhaps, that the nation as a whole, and those especially who have the government, public or private, of large groups of men in their hands, have learned that obedience to physiological law is a first necessity for the maintenance of the body machinery in health and for its effective and harmonious use. They have come to know, moreover, that the men who alone can guide them to this obedience are those who have learned in the school of investigation from Nature herself. The nation has seen a Minister fall whose control of the people's food was not based on physiological law, and his successor gain renown whose adoption of the teaching of physiological experiment was early and faithful. Nor was this by any means an isolated object-lesson. There is no doubt, surely, that physiologists have a new vista before them of immense public usefulness, if they will hold themselves in readiness to give the same kind of service to the country in the stress of her industrial life during peace as they gave so freely and to such effect in time of war.

But if the War brought these lessons to the general public, what lessons have come from it to the physiologist himself? I would only recall briefly here the considerations which were brought home with sufficient clearness to us all, I think, during and after the closing stages of the struggle. The War, in the first place, displayed before us new and gigantic fields of physiological study. Viewing these so far as we can, even at this distance, dispassionately, we see how the stresses

and accidents of warfare in all their variety offered to our study a series of experiments made upon the human body, and on a gigantic scale. Only by disciplined study of the results at all stages of these trials of war in all their varying degrees of horror and distress could effective aid be given in palliation of suffering or its avoidance. It was inevitable that study of this kind and upon so great a scale should result—as, happily, it did result—in much permanent gain to physiological knowledge and to the beneficent power that all sound knowledge brings. New insight was given into the functional patterns of the nervous system and into the orderly hierarchies, so to speak, under which this or that function is brought into subordination to another of superior rank, and new knowledge was gained of the phenomena of separation and repair in the outlying nerve-trunks. Accurate information was collected of the nutritional needs, quantitative and qualitative, of human beings under varying conditions; and, in particular, many special conditions of warfare brought to the test, established the fundamental usefulness, and stimulated the growth of that newest chapter in physiology already mentioned—that dealing with the elusive but potent accessory factors in nutrition—the vitamins. These examples must suffice where scores of others familiar to all of you might be given.

In the second place, the experience of the War has had wholesome effect from its tendency to remove the barriers that here and there had grown up between physiologists and the practical needs of medicine. Physiologists had valued, and justly valued, their academic freedom of inquiry within the universities, and indeed, we know that practical utility could not be better served in the long run than by the detached pursuit of knowledge for its own sake. But, partly for reasons of hospital and professional organisation already touched upon, and partly because, to its obvious and immense gain, physiology had attracted from other paths men who were not, and had never become, medical men, there were some capital parts of the subject of which the chief explorers had never used the medical field of work or brought to medicine the weapons they had, unwittingly, at command. We can recognise already that this partial divorce has been changed by the War into a union likely to be increasingly fertile. Of the professorial chairs of medicine or directorships of medical units established since the War, for the advance of medical knowledge within hospitals in accordance with the university standards and ideals acknowledged in other subjects of study, it is remarkable that to the greater number of these there have already been appointed men whose training has been in the methods of physiological laboratory, and who applied that training to urgent medical problems of the War. There is hardly any one of our schools of physiology, moreover, to which some piece of living experience has not been brought in these last years to enforce the old lesson of the value to science itself of bringing natural knowledge to its fullest utilitarian applications. The practical fruits of scientific labour are found, if our hands are put out to gather them, to contain within themselves, like the natural fruits of the earth, the very seeds from which new knowledge and new fertility will spring. Many of our leaders in physiology brought to the problems of war the accumulated knowledge of their lives, as patriotism and humanity dissolved at a touch the hedges of custom and use. I know of not one such who did not find in the application of his vision and training to the actual problems before him, first, a wholesome reminder of the limits of his knowledge and its clarity, and, second, new clues towards its advance, and that by no means only in a familiar or an expected direction. The stimulus of practical need here, as so often in experience, advanced the growth of knowledge beyond the point of immediate application to practice. Those who studied to find the best and most practical means of saving life threatened by severe hæmorrhage, or by the shock of wounds or operation, found in the course of meeting the immediate emergencies almost endless promptings to further enquiries, to be followed then or later—inquiries into the physical, chemical, or biological qualities of the blood, into its relations to the vessel walls, and into the functional changes of the capillary blood system and the factors affecting or controlling them. Those who fixed their attention upon the damage wrought in the respiratory organs by poison gases were led to many new studies of the fundamental physiology of the lungs. The lymphatic system of drainage of the lungs was re-examined, and wide new experimental studies of the modes of regulation of the breathing were undertaken which have thrown new and valuable light upon the normal mechanisms of respiration. An inquiry into the poisonous action of the high-explosive trinitrotoluene, and into the possibility that slightly abnormal forms of this substance, found as a small contamination of the normal form, might be specially toxic, led to a clear negative answer. But it led unexpectedly, it is both curious and useful to note, to the discovery that one of these abnormal forms was an effective reagent in the laboratory. By its means the chemical structure of a constituent of muscle substance known as carnosin was for the first time determined, and carnosin has now been synthesised artificially from simple materials.

In sum, then, we may gratefully recognise that the War in its horror and waste has not brought evil without any admixture at all of good. We may be encouraged at least to hope that the active co-operation which the War established and fostered in diverse ways between the physiologist and the medical or surgical clinician may remain to bring lasting good, on the one side to the cause of learning and its advance, and on the other to medical education and to medical progress.

III.

If we have looked backward to the development of physiology in the past half-century, and to the influence upon its course which the War has brought about, I would invite you to look forward to the future and to review the aims of physiology and the boundaries to which it should properly extend in its relations to other subjects of study.

Foster, early in his work at Cambridge, spoke of physiology as being the study of the differences between the living body and the dead body. The progress of this study, as it has been carried on during the past generation, may be considered from two directly opposite points of view. Viewed in one way, we may think of this progress as being

a progress in analysis, as a disentanglement of the diverse though not separable functions of the body and of each of its parts. Viewed again, we may see it as a steady progress towards synthesis, towards the unification of all the contributory functions of the parts into a single functional organism.

The analysis of the separate functions of each part of the body was an inevitable mental process as the anatomist revealed more and more accurately the visible machinery of the body. Bichat at the beginning of the nineteenth century had taught that the activities of the body must be the sum of the activities of the organs. The announcement of the universal cellular structure of the organs made by Schwann seemed but to carry this analysis one step further, and to show, that in the sum of the activities of the constituent cells could be found the adequate expression of the functions of the whole body. The rapid improvement of the microscope in the latter half of last century, combined with the new resources of the aniline dyes by which transparent structures could be differentiated and made visible, greatly stimulated the analytic study of the body. As the various glandular structures were made visible, and even, as it almost seemed, the inner life of the gland cell was revealed, as muscle fibres in their different kinds were made plain and the harder elements of the body resolved into the architectures due to different kinds of constructive cell, so it seemed to many that in a little more we should have the quest resolved in an appeal to a congeries of physico-chemical events within the individual cells. Even the mysteries of the central nervous system seemed to be dissolving as the new powers of histology, coupled with refined methods of experiment, showed the intricate pattern of communicating fibre and cell and gave provisional descriptive explanations of many isolated nervous phenomena.

(To be continued).

NOTE ON THE FORMATION OF HEXACHLORETHANE FROM CHLORPICRINE.

By OSWALD SILBERRAD.

WHEN hydrochloric acid gas is passed through chlorpicrine at 100° C. and the mixed vapour so obtained through a tube filled with pumice and heated to 400° C., the bulk of the chlorpicrine suffers decomposition into phosgene, nitrosylchloride and nitric oxide; a small proportion is, however, converted into hexachlorethane, which may best be collected by passing the cooled gases through a tube lightly packed with asbestos. On extracting the asbestos with a mixture of alcohol and ether, the hexachlorethane was obtained as rhombic tablets which volatilised without melting, but on heating in a sealed tube after re-sublimation, melted at 189° C., and proved on analysis to be hexachlorethane.

Found Cl=89·2 per cent. C_2Cl_6 requires Cl=89·85 per cent.

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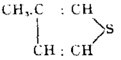
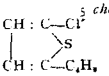
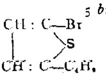
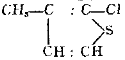
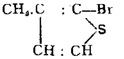
NOTE ON NEGATIVE OPTICAL ANOMALIES.

By GERVAISE LE BAS, B.Sc.

THE writer has recently pointed out the prevalence of negative anomalies which affect atoms like bromine, oxygen, and sulphur in organic compounds. These signify a depreciation of the optical refractivity below the normal atomic values as found in saturated compounds.

One of the outstanding facts is that the depreciations amount to −0·52, −1·06, and values involving the disappearance of r_a >O (1·48) and r_a : O (2·24).

Among the series of compounds which are affected are furfurane C_4H_4O −0·52, thiophene C_4H_4S −1·10. It has been shown that substituted furfurane compounds like furfural do not show this negative anomaly. The following thiophene derivatives give results from which additional conclusions may be drawn: CH_2 4·60, S 7·96, Cl 5·96, Br 8·79, r_a S 6·86 (lower value).

	M_a	Σr_a	Δ
3 methyl thiophene 	30·06	29·80	+0·26
5 chloro 2 butyl thiophene 	48·62	48·50	+0·12
5 bromo 2 butyl thiophene 	51·27	51·33	−0·05
2 chloro 3 methyl thiophene 	34·10	34·70	−0·60
2 bromo 3 methyl thiophene 	36·86	37·53	−0·67

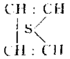
The nett value for sulphur in thiophene is r_a S 7·96−1·10=6·86, is entitled to be regarded as the characteristic one, since it fits in between Cl r_a 5·96 and P 7·77. The atomic refraction of sulphur in the mercaptans, thio ethers, &c., viz: 7·96, would thus show a positive anomaly of +1·10 (8×0·14) *cp*:

R_a H_2S	8·91	r_a S	6·79
H_3P	10·95	r_a P	7·77

(Bleekrode: Jamin's "Cours de Physique" III., p. 36).

The above Table shows that (1) substitution a 2 in position 3 can reduce the negative anomaly to zero. Perhaps positions 1 and 3 are nearer than shown by the formula (central position of

sulphur); (2) substitution on both sides of the sulphur atom practically neutralizes the negative anomaly; (3) the full substitution of one ethenoid group or substitution on one side of the molecule reduces the negative anomaly to half, −0·60 (4×0·15); (4) Cl, Br, have lost their usual positive anomalies for substitution



It is clearly seen that anomalies analysed as done by the writer in such a way as to distinguish between the two sides of conjugated unsaturated groups is the only one possible. This method of attack appears to make it necessary to recognise electrons as the units which retard the light, and that in some cases they fail to do so. An internal coordination of the electrons or leakage might be responsible. This condition sometimes affects a large number as shown *by the disappearance of the atomic refractivity.* The electrons of negative atoms seem specially prone to lose their influence, *e.p.*, . CH : N . in pyridine 1 : 1 0·78 only.

PROCEEDINGS OF SOCIETIES.

ROYAL SOCIETY.

November 10, 1921.

PROF. C. S. SHERRINGTON, President, in the Chair.

THE following papers were read:—

"*Experimental Researches on Vegetable Assimilation and Respiration. XIV.—Assimilation by Submerged Water Plants in Dilute Solutions of Bicarbonates and of Acids: an improved Bubble-counting Technique.*" By A. J. WILMOTT.

By the aid of special apparatus described in the text of the paper it is shown that the increase of "bubble rate" of CO_2 liberated from the cut stem of a water plant, found when free acid is added to the water covering the stem, is due to the effect of the acid upon carbonates present. No increase is found when soft water is used.

A comparison has been made in the "bubble rate" in solutions of carbonic acid and of sodium bicarbonate of known strength, and the latter were found to behave generally like solutions of carbonic acid.

"*The Coagulation of Protein by Sunlight.*" By E. G. YOUNG.

"*Optical Rotatory Power of Crystalline Ovalbumin and Serum Albumin.*" By E. G. YOUNG.

"*Longevity of Certain Species of Yeast.*" By A. R. LING and D. R. NANJI.

Eight cultures of yeast prepared in 1887 by the late Prof. Hansen were found to be still living. In what form they have retained their vitality we have not been able to determine. From the work of Hansen we know that one species at least, *A. apiculatus*, found on the exterior of certain fruits, hibernates in the soil; and as this species, or at all events the yeast with which Hansen worked, does not form endospores, it may be that our yeasts have been preserved as resting cells. Further experiments with these and other species of yeast are in progress.

"*A Quantitative Analysis of the Growth of Helianthus annuus. Part I.—The Respiration of the Plant and of its Parts throughout the Life Cycle.*" By F. KID, C. WEST, and G. E. BRIGGS.

The respiration of the plant was investigated first, to provide data for calculating loss in dry weight of a plant, due to respiration under field conditions, and thus, with data for increase in dry weight, due chiefly to assimilation, to construct a "balance sheet" for the plant; secondly, to determine effect of age of the plant (internal factor) upon its respiration. Respiration was measured under standard conditions at weekly intervals throughout the life cycle. Standard conditions were—a temp. of 10° C. (at this temperature respiration maintained a constant value for an appreciable time), excess of respirable material (directly after a period of active assimilation), external pressure of oxygen greater than in atmosphere.

The amount of carbon dioxide (mgrms.) per grm. dry-weight per hour produced by the respiring tissue under standard conditions is called the "respiratory index." Consequently the "respiratory index" is a close measure of the "effective amount of respiring cell-matter"—the internal factor involved in respiration. Further, for the first purpose, namely to determine loss in dry-weight due to respiration under field conditions (to be dealt with in later papers), the relation between respiration and temperature (0°-25° C.) was determined.

The "respiratory index" of the whole plant falls continuously throughout the life cycle from 3 to about 0·3. The respiratory index of stem, of individual leaves and of flower decreases with age of the organ. The initial "respiratory index" of successive leaves—*i.e.*, the "respiratory index" of the stem apex—decreases with age of plant, thus indicating that the effective amount of respiring cell-matter per grm. of dry-weight of meristematic tissue decreases with age of plant. Consequently, the fall in "respiratory index" of the whole plant is not due solely to increasing proportion of non-meristematic tissues, such as mechanical and water-conducting tissues.

Fall in the value of the "respiratory index"—rate of respiration per grm. dry-weight—follows closely fall in "relative growth rate," that is, rate of increase in dry-weight per grm. dry-weight, thus suggesting some close relation between increase in dry-weight and respiration.

"*The Colouring Matter of Red Roses*" By G. S. CURREY.

MINERALOGICAL SOCIETY.

November 1, 1921.

DR. A. HUTCHINSON in the Chair.

"*The Determination of the Optic Axes of a Crystal from Extinction-angles.*" By Prof. H. HILTON.

The problem of obtaining the positions of the

optic axes of a crystal from the extinction-directions on four known faces was discussed, and it was shown from a purely geometrical standpoint that the solution is unique Their position was also found graphically as the intersection in the gnomonic projection of two cubic curves, on which any number of points can be obtained by the use of the ruler only.

"Some Minerals from Leadhills." By W. Campbell Smith.

Caledonite of pale-blue colour and acicular habit have been frequently described in the past as aurichalcite. Examination of all available specimens of so-called aurichalcite from this locality showed that all were caledonite of this acicular habit. The optical properties were found to agree with those of caledonite of the normal habit. It was shown that in caledonite the plane of the optic axes is parallel to (010) and the acute bisectrix is perpendicular to (100) and not as stated in Dana and other text-books. Other remarks referred to gold, linarite, minium, and the rare mineral eosite.

"An Example of Porphyry-Quartz from the Esterel Mtns. (France) twinned on the face (1012)." By Dr. J. Drugman.

This twin-law in quartz has previously been observed only by Q. Sella in 1858 and has been regarded as doubtful. An example of it has been found amongst the porphyritic crystals in the "blue porphyry" of the Esterel Mtns. A distinction is made between the twins of low-temperature rhombohedral α-quartz and those of hexagonal β-quartz (stable at a temperature above 575° C.).

"Biographical Notices of Mineralogists recently deceased; with an Index of those previously published in the Mineralogical Magazine." By Dr L. J. Spencer.

NOTICES OF BOOKS.

Applied Colloid Chemistry, General Theory. By Wilder D. Bancroft. First Edition. International Chemical Series. Pp. 345. New York: McGraw-Hill Book Co. London: 6 and 8, Bouverie Street. Price 18s. net.

The increasing knowledge of colloidal chemistry has been remarkable during the last few years, and the part played by colloidal substances in every branch of chemistry, manufactures, and indeed in everyday life, is becoming recognised.

Professor Bancroft's book is a very valuable contribution to our knowledge of these substances. The author's work as Professor of Physical Chemistry in Cornell University is well known, and he has dealt with the subject in an original and masterly manner.

A large number of references to authorities is given in the text. This method of giving references is of the greatest value to students. It adds much to the usefulness of the work. It is intended that this volume shall be followed by others on such subjects as paints, varnishes, plastics, fibres, dyeing, foods, beverages, &c. We await these volumes with interest.

The Chemistry of Synthetic Drugs. By Percy May, D.S.C. (Lond.), F.I.C.). Third Edition revised. Pp. xv.+248. London: Longmans, Green & Co. Price 12s. 6d.

We are glad to announce the third edition of this most important work. The author in the preface of his second edition, published in 1918, remarks that before the war the manufacture of synthetic drugs was practically confined to Germany. The unhappy use that that nation made of the knowledge gained by the research in this domain is now a matter of history. The war with all its horrors has shown the unsuspected toxic action of many of these little-known gases. It has shown, for instance, that the material now known as phosgene (carbonyl chloride) is far more toxic to man than prussic acid, and the hitherto almost unknown substance—di-chlorethyl sulphide (familiar to everyone by the name of mustard gas)—has been found to be one of the most dangerous substances known.

During the war and since the armistice, the manufacture of synthetic organic chemicals has been undertaken by British chemists with considerable success, but to enable them to hold their own against competition from a country where factories completely equipped for producing these substances are already in existence, some kind of protection is necessary. Assistance of this kind will probably be obtained in measure, and with the increasing knowledge of their chemistry and experience in their production, there should be nothing to prevent their home manufacture in sufficient quantity to meet all needs.

The value of synthetic drugs in pharmacology cannot be over-rated, but an exhaustive knowledge of their chemical composition and physiological action alone enables them to be produced economically and applied to the greatest advantage.

Dr. May's work is an invaluable contribution to the knowledge of the subject. The work is well printed and indexed, and there is a useful glossary of chemical and medical terms that is of considerable value.

Inorganic Chemistry. By E. J. Lewis, M.A. (Cantab.), B.Sc. (Lond.), with Introductory Note by Sir Richard Threlfall, K.B.E., M.A., D.Sc., F.R.S. Pp. xv.+442. Cambridge University Press. Price 9s. net.

In the introductory note Sir Richard Threlfall, while referring to the effort that had to be put forward during the war to put the manufacture of explosives on an adequate basis, called the attention of very many to the important part that chemistry plays in the life of the nation—with the result that a number of young men hastened to take up chemistry as a profession—and his introductory note is specially directed to such. He emphasises the need of a thorough chemical education. "There is always an opening for a good chemist, industrious, clear-headed, logical, and persistent, with a knowledge of the subject wide enough and deep enough to give these faculties full play. There is no room nor prospect for the smatterer."

The book is exceptionally well illustrated, and will be found invaluable to students and to those who propose to adopt chemistry as a profession.

The first part of the book is divided into sections deaing with equivalent mass, the atomic theory and its applications, while Part II. is occupied with the Periodic Law.

Mendeleef's periodic classification and Lothar Meyer's curve showing the relation between atomic volumes and atomic weights are given.

We notice that some of the statements made are open to a certain amount of criticism. For instance, on page 398 it is stated that Crookes in 1878 discovered cathode rays. This is more than Sir W. Crookes himself claimed, for although his researches into radiant matter at that time brought the subject into great prominence, cathode rays had been observed and described some years earlier.

On the same page also it is suggested that Roentgen in 1895 discovered that when the cathode rays were stopped by a solid target they gave rise to X-rays. It is doubtful whether the true explanation or the true physics of the conversion of cathode rays into X-rays was understood before the introduction of Prof. Jackson's *platinum target tube*.

The Electric Furnace. By J. N. PRING, N.B.E., D.Sc. Pp. ix.+485. London: Longmans, Green & Co. Price 32s. net.

This further valuable addition to monographs on industrial chemistry cannot fail to be of service to those who are working with numerous reactions connected with the very high temperatures. Although a knowledge of the chemical effects that can be produced by electricity dates back to the days of Davy in 1810, it is only in recent years that the electric furnace has become one of the most valuable agents in metallurgical processes. The remarkable researches by the late Henry Moissan in France and the more recent results in London and America have brought home to metallurgists the value of electricity in producing high temperature.

A very complete historical survey of the subject is given in the first chapters, and the various devices that have led up to the present-day methods are fully and clearly illustrated. This is followed by a description of present-day electric furnaces, and the details of the current supply in electric furnace operations.

A good chapter is devoted to measurement of high temperatures and is followed by a description of the methods at present employed for the manufacture of calcium carbide and the synthesis of nitrogenous compounds.

The electric steel processes that have recently played such an important part in the production of high-grade steel are fully dealt with, and most of the systems in present use are fully described and illustrated.

At the end of the book the power expenditure in electric furnace processes in connection with cost is discussed, and statistical information is given of present-day water power and steam-power installations.

A valuable bibliography of books on electric furnaces, ferro-alloys, non-ferrous metals, abrasives, and kindred subjects brings the book to a conclusion.

Volumetric Analysis for Students of Pharmaceutical and General Chemistry. By CHARLES H. HAMPSHIRE, B.Sc. (Lond.), F.I.C. Pp. 124, fully illustrated. London: J. & A. Churchill. Price 7s. 6d. net.

In this edition of this useful little book some new determinations have been added, and also the section on indicators. The object of the book is twofold—to present a general introductory course of volumetric analysis as well as an additional specialised course for students in pharmacy and analytical chemistry.

The first two chapters deal with the proportion of normal solutions, and then follows a very important chapter on the sources of error in indicators, which is of very great value, as it makes clear many little known reactions that would otherwise cause considerable perplexity to students.

The exercises in acidimetry and alkalimetry that follow are very clearly and simply arranged. The next section of the book deals with oxidation and reduction, and the concluding pages are devoted to miscellaneous exercises.

The book is well indexed and illustrated and will undoubtedly be largely used by workers in volumetric analysis.

The Chemical Effects of Alpha Particles and Electrons. By SAMUEL C. LIND, Ph.D., Physical Chemist, U.S. Bureau of Mines. American Chemical Society, Monograph Series. Pp. 182, illustrated. New York: Chemical Catalogue Co.

This book is the second of the American Chemical Society's series of monographs, and it deals in a systematic manner with what is of necessity an entirely new branch of chemistry. The object of the author of the monograph has been to collect together as much experimental material as possible, and to present it in a form that can readily be followed by those who are unfamiliar with the subject.

Although from the title one would perhaps conclude that the work would be confined to the effect of alpha particles and electrons, the field of photo-chemistry is of necessity introduced. The author acknowledges his indebtedness to the work of Rutherford, Madame Curie, J. J. Thomson, and others.

Chapter I. is devoted to the definition of radiochemistry, and the author explains in some detail what should be comprehended in the term.

Chapter II. gives a brief outline of radioactivity and the properties of some special forms of radium. This is followed by a chapter on ionisation and qualitative radio-chemical effects. The author gives a very brief account of the colouration of glass and minerals by the action of alpha rays. This reaction was very carefully studied by the late Sir William Crookes, particularly the colouration brought about by the action of alpha particles upon diamonds, and by sunlight upon glass.

Chapter VI. deals with the reactions by radium emanation and the experiments of Cameron and Ramsay are fully described and illustrated.

Disintegration by alpha particles is also discussed, and a review is given of the investigations by Rutherford, Darwin, and others, on this im-

portant subject. The final chapter is devoted to artificial radio-activity. The appendix gives useful tables of the decay of radium emanation, and a list of radio-active isotopes. At the end of the book there is a very complete index of subjects, followed by a list of authors quoted. The book is thoroughly well printed and illustrated.

CORRESPONDENCE.

GRAPHIC REPRESENTATION OF CERTAIN HETEROGENEOUS EQUILIBRIA.

To the Editor of the Chemical News.

SIR,—The remarks of Rivett (CHEMICAL NEWS, cxxiii., No. 3213) appear to be somewhat superfluous. In his paper the following phrase occurs: "The phase rule requires variation in the solid phase in binary systems to correspond with variations in the liquid phase." Is not this variation adequately represented by the ordinate A / *a* in his diagram?

In the figure each point denotes a substance of invariant properties. The ordinate A / *a* on the other band represents the variation in properties of the pure substance A, implicitly if not explicitly.

Obviously, this being true the point A denotes a different substance to the points *f-a*, this variation in properties would include changes in density, electrical conductivity, vapour pressure, and other physical properties.

Would not this variation in physical properties correspond to the excessively minute changes in the solid phase which Rivett holds to be necessary?

From this point of view any substance at say 30° C. is held to be different to the same substance at, we will suppose, 65° C.

The same argument can be presented from a somewhat different viewpoint, taking the case of a homogeneous equilibrium. Consider an enclosed volume of two non-reactive gases. These may be considered to be in "equilibrium at any given temperature, yet obviously the type of equilibrium will vary with the corresponding change of temperature, the velocity of the molecules mean free path, kinetic energy and viscosity changing.

This demonstrates quite clearly the variation in properties with temperature necessary for the maintenance of equilibrium.—We are, &c.,

CLAUDE W. L. BOURLET
WIDGEY R. NEWMAN.

CHEMICAL NOTICES FROM FOREIGN SOURCES.

Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences. Vol. clxxiii. No. 14.

"Action of the Infra-Red Rays on Phosphorescence." By M. Maurice Curie.

No. 15.

"Absorption Spectrum of Oxygen." By MM. J. Duclaux and P. Jeantet.

"The Sub-bromide of Tellurium." By M. A. Damiens.

"The Constitution of the Polysulphonated Derivatives of Indigo." By M. Grand Monezin.

No. 17.

"A New Method of Determining Silica." By M. Travers.

"Dibromoanthraquinone used for the Synthesis of Alizarine." By M. Grand Monezin.

NOTES.

ROYAL SOCIETY OF ARTS.—Meetings for the week ending November 26, 1921: Wednesday, Nov. 23, at 8 p.m.—"Trueman Wood" Lecture, "The Coming of Age of Long-Distance Wireless Telegraphy and some of its Scientific Problems," by Prof. John Ambrose Fleming, M.A., D.Sc., F.R.S., Albert Medallist. Alan A. Campbell Swinton, F.R.S., Chairman of the Council will preside. Friday, Nov. 25, at 4 p.m.—Dominions and Colonies and Indian Sections (Joint Meeting), "An Imperial Airship Service," by A. H. Ashbolt, Agent-General for Tasmania. Brig.-General Lord Montagu of Beaulieu, K.C.I.E., C.S.I., will preside.

BLEACHING PALM OIL.—A very simple process has, it appears, given excellent results in Germany. It merely consists in moving a metal sieve, with fine meshes, upwards and downwards in the oil at a temperature of 100° C. Bleaching is produced by the frequently renewed atmospheric oxygen. Thus bleached, the oil could be utilised instead of copra oil for alimentation.—*Revue de Chimie Industrielle*, October, 1921.

AN interesting paper by E. L. Nichols and D. T. Wilber has recently been published in the *Physical Review*, No. 6, xvii., June, 1921, on the "Luminescence of Certain Oxides Sublimed in the Electric Arc." From the synopsis it appears that "oxides prepared by sublimation are found to respond to excitation by cathode rays, as well as to flame excitation through a wide range of temperatures. The temperature at which excitation ceases is in general the same, taking each band separately, for flame excitation and for cathodo-excitation. The shift in the colour of luminescence is in general towards the violet with rising temperature. This shift is produced by the independent growth and decadence of over-lapping bands and not to any lateral movement of the bands themselves. Certain bands in the spectra of these oxides are most strongly excited by cathode rays at relatively high pressures, others appear as the vacuum becomes more complete, so that as exhaustion progresses there are marked changes in the colour of luminescence.

NEW BOOKS.—A new series of volumes, to be published by George Routledge & Sons, Ltd., under the title "Twentieth Century Chemistry," is in preparation under the Editorship of Sir William Tilden, D.Sc., F.R.S., Emiritus Professor in the Imperial College of Science and Technology, South Kensington, and Dr. J. C. Philip, F.R.S., Senior Secretary of the Chemical Society and Professor of Physical Chemistry in the Imperial College. The intention is to provide works of moderate size and price in all the more important sections of scientific chemistry, suitable for post-graduate readers and others possessing

sufficient elementary knowledge. The aim will be to produce readable and interesting books which, without being exhaustive monographs, will furnish advanced students with a complete survey of the present state of knowledge and opinion in each branch of the science. Several distinguished chemists, both British and foreign, have promised to assist by contributing volumes to the series.

New Method for Manufacture of Synthetic Nitrogen.—A new process has, according to *Chimie et Industrie*, been invented by an Italian, Dr. Caze, for manufacture of synthetic ammonia. The requisite hydrogen is obtained by electrolysis of water and the nitrogen extracted from the air by a secret process by aid of an automatic machine working continuously. The two gases are combined at a low temperature in presence of catalysers. The works in Turin initially produced 300 kilogrms. of pure ammonia per diem. It was enlarged last December, and now produces 1000 daily. Finally the ammonia can be transformed into urea, which, as it contains 40 per cent nitrogen, is a very valuable fertiliser. In the invention of Prof. M. Andreucci of Rome, atmospheric nitrogen is obtained by the explosion of a mixture of 100 litres of air (containing 200 litres of oxygen) and 418 of hydrogen in an internal combustion engine (benzine; poor gas; lighting gas; or Diesel) provided with an electric system of ignition. The product obtained consists of approximately 336 grms. of water and 778·3 litres of almost pure nitrogen, with various foreign substances which are removed by chemical means. The motor utilised is adapted for the purpose by narrowing the air and hydrogen intake passages so as to obtain suction in the required proportion to prevent excessive pressures of explosion. A Watt indicator is utilised for the purpose—*L'Engrais*, July 22, 1921.

New Patents.

This List is specially compiled for the *Chemical News* by Messrs. Rayner & Co., Registered Patent Agents, of 5, Chancery Lane, London, W.C.2., from whom all information relating to Patents, Trade Marks and Designs can be obtained gratuitously.

Latest Patent Applications.

28557—Cumberland Coal, Power & Chemicals, Ltd.—Manufacture of ammonia sulphate, October 27.
28293—Jones, B. D.—Process for production of sodium pentaborate from boren ores. October 25.
28435—Kelly, A.—Treatment of mineral phosphites. October 26.
28325—Society of Chemical Industry in Basle.—Manufacture of dye-stuffs of the triarylmethane series. October 25.

Specifications published this Week.

149001—Muth, G.—Process of preparing aluminium sulphate
147030—Westling, E. H.—Process for the production of manganese dioxide.
147909—Goldschmidt Akt. Ges.—Process for the production of ethylene chloride.

Abstract Published this Week

Toluene Derivatives. *Patent No. 169,025.*

A process for obtaining Toluene Derivatives is the subject of a Patent granted to Mr. A. D Clibbens, of Crumpsall Vale Chemical Works, Blackley, Manchester.

By the chlorination of toluene-p-sulphonic acid or monochlorotoluene-p-sulphonic acid in aqueous solution, a mixture of 2·5-dichloro and 2·5 6. trichloro-toluene-4 sulphonic acids is produced, from which the trichloro body is precipitated by neutralization with alkali, leaving the dichloro compound to be recovered by evaporation of the mother liquors. Instead of the free acids, their soluble salts may be used as starting material. On hydrolysis, the products yield 2.5-dichlorotoluene and 2.5.6-trichlorotoluene respectively.

Sulphur Dioxide. *Patent No. 168627*

A process for obtaining sulphur dioxide has been patented in this country by Mr. A. H Eustis of Milton, Norfolk, Massachusetts, U.S.A. The product is obtained by separation from gas mixtures such as smelter smoke by absorption in and extraction from a liquid. The extraction from the liquid being effected by reducing the partial pressure of the sulphur dioxide in the atmosphere contracting with the liquid by diluting with a copious supply of gas such as steam which is condensible at lower pressure and/or higher temperature than sulphu dioxide.

Messrs. Rayner & Co., will obtain printed copies of the published specifications and will forward on post free for the official price of 1/- each.

NEW COMPANIES.

The under-mentioned particulars of New Companies recently registered are taken from the Daily Register compiled by Jordan & Sons, Limited, Company Registration Agents, Chancery Lane W.C.2.

Western Chemical Company, Limited.—(177674)—Registered 4th November, 1921. To carry on the business of Manufacturers and Dealers in Chemicals, Glues, &c. Nominal Capital: £3,000 in 2,000 Ordinary Shares of £1 each and 4,000 Shares of 5s. each. Directors: To be appointed by Subscribers. Qualification of Directors: One Share. Subscribers: J. S. Mason, Chester Cottage, Hassocks, Sussex; W. J. Knight, "Cantara", Field Way, Ruislip, Middlesex.

Hygeia, Limited.—(177660)—Registered 4th November, 1921. 85, Gracechurch Street, E.C. To carry on the business of Chemists and Druggists. Nominal Capital: £10,000 in 10,000 Shares of £1 each. Directors: To be appointed by Subscribers. Qualification of Directors: £300. Remuneration of Directors: To be voted by Company in General Meeting.

NOTICES.

EDITORIAL.—All Literary communications and Books, Chemica Apparatus, &c., for review or notice to be addressed to the Editor.

SUBSCRIPTIONS, £1 12s. per annum, payable in advance should be addressed to the Manager.

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THE CHEMICAL NEWS.
VOL. CXXIII., No. 3215.

THE COAGULATION OF COLLOIDS BY ELECTROLYTES.

By HUMPHREY D. MURRAY,
Exhibitioner of Christ Church, Oxford.

WHEN Graham first came to study colloidal substances, he noticed as one of their most characteristic properties their coagulation in the presence of electrolytes. Since that time more work has been done upon this particular aspect of the subject than possibly any other, and most workers seem to have realised that a true insight into the mechanism of coagulation will illuminate the whole subject of the stability of the colloid particle. The object of this paper will be to review the work done by various chemists upon coagulation, more particularly within the last few years.

Two series of experiments were carried out by Schulze (*Jour. Prakt. Chem.*, 1882, xxv., 431; 1883, xxvii., 320; 1884, xxxii., 390) and Linder and Picton (*Jour. Chem. Soc.*, lxi., lxvii., lxxi., and lxxxvii), which have had considerable influence upon all later work. Previous to this, Jevons (*Trans. Manch. Phil. Soc.*, 1870, p. 78) and Gouy (*Comptes Rendus*, 1889, cix., 102) had reached the conclusion that most colloid particles carried an electrical charge, and this belief has since been amply confirmed. These researches of Schulze and Linder and Picton made it plain that the factor which most directly influenced coagulation was the concentration of the ion bearing a charge opposite in sign to that of the colloid. Moreover, it was found that trivalent ions were more effective in producing coagulation than divalent, and the latter in their turn were more effective than univalent ions. It was found, however, that there were distinct variations in the coagulative powers, or the reciprocals of the least concentration required to bring about coagulation, of ions of similar valency; but this variation seems rather to have been lost sight of in viewing the larger effect caused by difference in valency. Whetham (*Phil. Mag.*, 1889, xlviii., 474) suggested from the theory of probabilities that the coagulative powers of univalent, divalent and trivalent ions respectively would he in the ratio $x : x^2 : x^3$ where x is some constant. This suggestion seemed to receive support at the time from the averaging of Linder and Picton's results, but as experimental work accumulated, its validity has been seriously called in question, until now it would seem safer scarcely to regard it even as a rough generalisation.

During their researches upon the negatively-charged arsenious sulphide Linder and Picton analysed the precipitate carried down when barium sulphate was added to the solution in in sufficient quantity. They found that the positive barium ion was entrained by the coagulum and intimately bound up with it, but that the sulphate ion was entirely absent. Experiments by other observers led to a similar conclusion, namely, that the coagulum always adsorbed a portion of that ion which was active in producing coagulation. Whitney and Ober (*Jour. Amer. Chem. Soc.*, 1901, xxiii., 842) confirmed the work of Linder and Picton, and came to the further conclusion that the active ions were always carried down in quantities which were equivalents. This would mean that each ion has a specific action of its own, and the decisive factor in conditioning coagulation is not necessarily its valency.

We can observe the action of salts in bringing about coagulation by examining the minimal quantity required, or by analysing the resulting coagulum, or directly by means of the microscope or ultra-microscope. This latter method has been employed by Cotton and Mouton ("Les Ultra-Microscopes"), Zsigmondy ("Zur Erkenntnis der Kolloide"), Galecki (*Zeit. anorg. Chem.*, 1912, lxxiv., 179), and others. Their researches have brought to light the fact that a small concentration of electrolyte causes no apparent increase in the size of the particles. Above this concentration the particles begin to condense, the larger serving as nuclei to the smaller, and the rate of condensation varies as the concentration of the colloid. This observation was borne out by Paine (*Proc. Camb. Phil. Soc.*, 1911, xvi., 430) working upon solutions of colloidal copper. He found that there was a definite initial period after the addition of the electrolyte when no coagulation occurred. When it started the rate varied as the square of the initial concentration of the colloid and also as some power of the concentration of the active ion. Some results by Galecki (*loc. cit.*) on solutions of gold sols are interesting. He added varying concentrations of $SrCl_2$ to a gold solution and examined th enumber of submicrons present in 1 cc. at the end of two days. On plotting the concentration of $SrCl_2$ against the number of submicrons, he failed to obtain smooth curves, but got curves of the general form shown in Fig. 1.

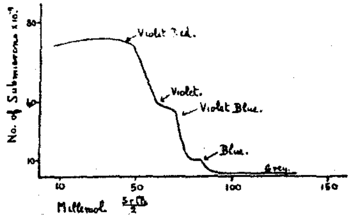

FIG. 1.

Similarly, on plotting the number of submicrons present in 1 cc. against the time elapsing after the addition of a definite quantity of $SrCl_2$, he obtained a curve of the form shown in Fig. 2. These curves were repeated with other electrolytes. They are interesting as seeming to show that coagulation, at least in the case of gold sols, takes place in stages, which are characterised by corresponding changes in colour.

The actual conditions under which the electrolyte has been added to the colloidal solution, and the subsequent treatment afforded to the resulting mixture, varied with each experimenter. In some cases the solution was titrated in the usual way

drop by drop; in other cases the mixture was made all at once, and the correct proportion found by trial and error. Sometimes the solution was shaken continuously during the addition; sometimes it was subsequently boiled. It

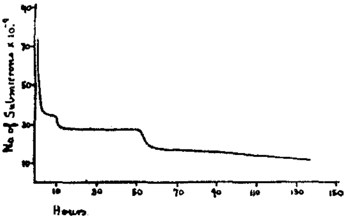

FIG. 2.

is not, therefore, permissible to compare the result of one worker with that of another. It should, however, be possible to compare one series so obtained with another; but when such a comparison is made we are met with numerous differences. To give but one instance—in the coagulation of arsenious sulphide, Linder and Picton (*loc. cit.*) deduce the following order for the coagulative power of the chlorides:—

$Na < K < NH_4 < H < Ni < Cd < Fe^{II} < Zn < Ca < Co < Sr < Ba < Mg < Hg < Pb < Fe^{III} < Al.$

While Schulze (*loc. cit.*) deduces the order for the sulphates:—

$K < Na < NH_4 < H < Mg < Fe^{II} < Ca < Mn < Ni < Zn < Al.$

And Freundlich (*Zeit. Physik. Chem.*, lxxiii., lxxix., lxxxiii., and lxxxvi.):—

$Li < Na < K < H < Mg < Ba = Zn = Be < Ca = Sr < Al = In = Ce.$

This variation in results can be ascribed to several possible causes. In the first place we have seen that the larger particles act as condensation nuclei to the smaller, and therefore a large difference in the size of the biggest and the smallest particles present will lead to the appearance of flocks in the liquid with a concentration of electrolyte smaller than that required to begin coagulation with a colloid of uniformly fine grain. This fact has been emphasized by Odén (*Zeit. Physik Chem.*, 1912, lxxviii., 682). He found that the point of coagulation was sharper with a suspensoid of uniform grain, and also that a greater concentration of electrolyte was required to begin coagulation with a suspensoid of a fine grain than with one of a coarse grain.

An interesting series of experiments have been carried out by Weiser and Middleton (*Jour. Phys. Chem.*, 1919, xxiii., 630; 1920, xxiv., 30) and Weiser and Sherrick (*Jour. Phys. Chem.*, 1919, xxiii., 203) upon the coagulation of ferric hydroxide and aluminium hydroxide. They have come to the conclusion that adsorption of the electrolyte takes place, not only in the case of the charged particles, but also in that of the neutral substance. They found that, if the electrolyte were added slowly enough, a greater quantity was required to produce complete coagulation than if it were added all at once. This extra quantity they ascribe to the amount of salt adsorbed by the flocks of colloid first coagulated. They also emphasize the fact that treatment of the solution in respect to shaking and change of temperature alters the amount of electrolyte required for coagulation. Weiser and Middleton also criticise Whitney and Ober's results showing that equivalent quantities of the active ion were carried down by the coagulum, and the grounds upon which Freundlich supported this view. Their results bear out the fact that adsorption is specific for each ion, but not that such adsorption is proportionate to the equivalents of the ions.

Until recently little attention had been paid to the absolute concentration of the colloid at the moment of precipitation, but Burton and Bishop (*Jour. Phys. Chem.*, 1920, xxiv., 703) have obtained a result previously indicated by Kruyt and Speck (*Koll. Zeit.*, 1919, xxv., 1) which in general would seem to show that this was of great importance. They studied the concentration of electrolyte necessary to produce coagulation in the case of solutions of As_2S_3, Cu, and mastic, when the concentration of the colloid varied. They found in the case of univalent ions that the concentration of the electrolyte varied inversely as that of the colloid, divalent ions were scarcely affected, while electrolytes, the active ion of which was trivalent varied directly as the concentration of the colloid. This result, they would suggest, is connected in some way with the concentration of the ion of same sign as that of the colloid. The effect of this ion has not generally been taken into account, but it must have some very definite bearing upon the subject. It may be noted in this connection that most colloidal solutions appear to have a saturation point and attempts to concentrate them beyond this point leads to continual coagulation of the colloid.

It may be useful at this point to summarize the facts which appear to have an important bearing upon the whole theory of coagulation, and also the precautions which appear necessary to ensure comparable results in coagulation experiments. Of the first we have:—

1. The specific action of the ion of opposite sign to that of the colloid in adsorption, and in bringing about coagulation.
2. The greater effect in general of ions of higher valency.
3. The modifying action of ions of same sign as that of the colloid.
4. The possibility that equivalent quantities of different ions are entrained by the coagulum.
5. A minimal concentration of electrolyte necessary before coagulation begins.
6. The effect of an ion originally present in the colloidal solution, to which little attention has been paid.

The precautions necessary to ensure uniform results which have already been discussed are:—

1. That the colloid have the same concentration in each case at the point of coagulation. This follows naturally if Burton and Bishop's work be found to have a general application.

2. That the electrolyte be quickly and uniformly mixed with the colloid. This may be facilitated by having the electrolyte in a dilute solution.
3. That the subsequent treatment of the solution in the matter of temperature and shaking be the same.
4. That the particles of the colloid be of uniform size.

It may be that these do not represent four independent conditions but that the variations introduced by their alteration are in some degree interdependent. Investigation of this fact should prove interesting and work on these lines is now being undertaken by the writer.

BRITISH STANDARD SPECIFICATION FOR CREOSOTE FOR THE PRESERVATION OF TIMBER.

[THE British Engineering Standards Association have sent a copy of the recently-issued Specification for Creosote, which we are pleased to publish. The Report can be obtained from the Offices of the Association, 28, Victoria Street, S.W.1, price 1s. 2d. post free.]

This Specification covers the requirements of Creosote suitable for the treatment of railway sleepers and telegraph, telephone, and hangar poles.

TYPE A.

1. DESCRIPTION.—The material shall consist essentially of a distillate of coal tar, and shall be free from any admixture of petroleum or similar oils.

2. SPECIFIC GRAVITY.—(See Appendix I.). The specific gravity shall be not less than 1·015 and not more than 1·07 at 38° C. (100° F.) when compared with water at the same temperature.

3. FLUIDITY.—The material shall become completely liquid on being slowly warmed to 38° C. (100° F.) with stirring, and on cooling down shall remain completely liquid after standing for two hours at 32° C. (90° F.).

4. WATER CONTENT.—The amount of water in the Creosote shall not exceed 3 per cent when determined by the method described in Appendix II.

5. DISTILLATION.—When 100 cc. measured at 38° C. (100° F.) of the dry Creosote are distilled from a 250 cc. distillation flask (see Appendix III.) at such a rate that the distillation is complete in about 20 minutes, there shall distil at 760 mm. pressure,

up to 205° C. (401° F.) not more than 7 cc.
,, 230° C. (446° F.) ,, ,, 40 cc.
,, 315° C. (599° F.) ,, ,, 78 cc.

the volumes of all fractions being measured at 38° C. (100° .).

The residue above 315° C. (599° F.) shall be soft and not sticky and its weight shall not be less than 22 grms.

6. TAR ACIDS.—The amount of tar acids when determined by the method described in Appendix IV. shall be not less than 5 per cent and not more than 16 per cent by volume.

7. MATTER INSOLUBLE IN BENZOL (BENZENE).—The amount of matter insoluble in benzol (benzene) shall not exceed 0·4 per cent by weight.

ADDENDUM.—TYPE B.

Alternative for Scotch Creosote.

Scotch Creosote shall conform to the above Specification with the following exceptions:—

2. SPECIFIC GRAVITY.—The specific gravity shall be not less than 1 at 38° C. (100° F.). In the case of the blast furnace oil the specific gravity may be lower, but shall not be less than 0·940 at 38° C. (100° F.).

5. DISTILLATION.—The distillate at 315° C. (599° F.) shall be not more than 85 cc. and the residue not less than 15 grms.

6. TAR ACIDS.—There shall be no limit to the amount of tar acids.

APPENDIX I.

Specific Gravity.

Care shall be taken to ensure that the Creosote is completely liquefied and homogenous before the sample is taken.

In the event of the temperature at which the determination is made not being exactly 38° C. (100° F.) the observed specific gravity (d) at the temperature t° shall be converted to "corrected" specific gravity D by means of the formula:—

$D = d + 0{\cdot}00075\ (t - 38)$
if t be in degrees Centigrade, or
$D = d + 0{\cdot}00042\ (t - 100)$
if t be in degrees Fahrenheit.

APPENDIX II.

Determination of Water Content.

The material shall be made completely liquid and homogeneous by warming to 38° C. (100° F.). 100 cc. of the liquid measured at 38° C. (100° F.) shall be mixed with 50 cc. of Xylol previously saturated with water and the mixture distilled from a distillation flask at a rate of about 3 cc. per minute. 50 cc. of distillate shall be collected in a cylinder of suitable size graduated in 1/5 cc. and the volume of water determined at room temperature.

The condenser used in this test shall be either a straight vertical condenser, or of such construction that it will readily drain completely.

APPENDIX III.

Distillation.

The Creosote shall be dried over calcium chloride, plaster of Paris or other suitable material, and 100 cc. of the dried Creosote measured at 38° C. (100° F.) placed in a tared standard 250 cc. Wurtz distillation flask, the neck of which is approximately 12 cm. long with outlet tube emerging approximately half way up the neck. The flask shall be furnished with a standardised thermometer, the top of the bulb of which is just below the outlet tube. The distillation shall be carried out over a free flame. When a temperature of 315° C. (599° F.) has been reached, the distillation shall be stopped, the flask and contents allowed to cool, and then re-weighed.

Correction for Emergent Thread of the Thermometer.

The number of degrees C (dt) to be added to the observed thermometer reading t° C. shall be

calculated from the following formula:—

$dt = 0{\cdot}000143\ (t-t')\ N$, where N is the number of degree divisions of thread exposed above the cork and t' the air temperature half way up the exposed thread.

When Fahrenheit thermometers are used, the formula shall be $dt = 0{\cdot}0000794\ (t-t')\ N$.

Correction for Barometric Pressure.

For every 25 mm. above or below 760 mm., 0·8 grm. (0·6 grm. in the case of Scotch oils) shall be subtracted from or added to the observed weight of residue in the flask.

APPENDIX IV.

Determination of the Tar Acids.

The tar acids shall be determined by complete extraction of the total distillate below 315° C. (599° F.) with caustic soda solution of specific gravity 1·18. The tar acids shall be separated from the soda solution by neutralising with sulphuric acid (specific gravity 1·35 at 15° C. (59° F.), *i.e.*, one volume of 1·84 acid mixed with two volumes of water) and their volume determined.

REPORT BY SIR PERCY GIROUARD, K.C.M.G. TO CLOSE BROTHERS & CO. LTD. ON THE OPERATIONS OF THE LOW TEMPERATURE CARBONISATION PLANT AT BARNSLEY, YORKSHIRE.*

Low Temperature Carbonisation.

FOR some years past I have been investigating the problem of the use of smokeless fuel, and though my studies have been mainly directed towards the use of coal in powdered form, a great development of which has been witnessed in the United States, my attention was also drawn to the various proposals for the low temperature carbonisation of small coals and slacks, which in all countries had a low value as compared with lump coal, and in some countries had practically no value whatever.

In June of this year I was asked by a mutual friend to look into the particular developments which had been carried out in England by Low Temperature Carbonisation, Ltd. Ascertaining that this organisation was the descendant of the original Coalite Companies, I was constrained to say that, though not antagonistic, as my knowledge of their operations was very limited, I could only enter into any investigation in a prejudiced spirit. Notwithstanding my attitude, you pressed upon me the national importance of the question, with the request that I should visit the Barnsley plant.

After my first visit, which proved of considerable interest, I informed you that if you desired me to go any further I should require complete independence in my investigations, and to be given the full confidence of the directors, staff, or engineers, and access to any documents I should require. This request was readily granted, and I may state at once that as from July until the present day one and all connected with the enterprise gave me every assistance and information I desired.

Manufacture.

On my first visit to Barnsley, where you had installed 20 retorts which were said to be capable of carbonising about 200 tons per week, I could not see the plant in actual operation, as it had been closed down in consequence of the coal strike. The strike perhaps had one advantage, it allowed of your introducing into the retorts a device which it was hoped would end one of the main difficulties which has always faced low temperature carbonisation, that of discharging the resultant Coalite (a smokeless fuel), which too often in the past had adhered so firmly to the walls of the retorts that extraction became a matter of the very greatest difficulty. In extreme cases it was freely admitted that several days passed after carbonisation before the coalite could be extracted. This led not only to high costs, but to the production of an inferior fuel, containing a high percentage of breeze.

The device, which I was enabled to see before its actual insertion in the retorts, consisted of a pair of collapsing plates which divided the coal charge into two halves. The plates were provided with holes at intervals throughout their surface. The coal was to be inserted in the retorts with the plates in an expanded condition, and means were provided by which they were readily collapsed. The results which were expected from this new and ingenious device were of the highest importance. It was expected:—

(1) That on collapsing the plates after carbonisation of the slack, the resultant Coalite would readily drop into a cooling chamber below;

(2) That during the period of carbonisation, the gases given off from the coal would readily escape through the orifices in the plates and not have to force themselves through a mass of hot coal occupying the whole retort;

(3) That the device would give a larger yield both of gas and of tar oils.

The hopes which were held out could not be ocularly demonstrated until a coal supply was available, and the retorts brought up to a low temperature heat, which was to be about 550° C. within the retorts.

The strike having ended, coal was shortly available, and the heating of the retorts was started early in August, and in the week ending August 25, 13 tons of coal were carbonised. From that week to the present day, the progress has been continuous, and in the last three weeks, ending October 6, approximately 150 tons of slack per week were carbonised, resulting in approximately 100 tons of Coalite per week, and a yield of 15-18 gallons of tar oils per ton of coal carbonised. During the whole period, from the starting of the retorts to date, 833 tons have been carbonised. Manufacture on such a scale cannot be considered to be of an experimental or laboratory character.

The devices which have been introduced have, therefore, had a very severe test, and they have gone through it with great success, more particularly under the circumstances of starting a new plant. Many difficulties militated against abnormal success. The washing appliances were not, and are not now, by any means perfect, and the

* Sir Percy Girouard's Report on the Low Temperature Carbonisation of Coal Slack is a matter of national interest, and with his permission and that of Messrs. Close Bros. & Co., at whose works the experiments were carried out, we are reproducing it in full.

fuel is therefore, at times, admitted to the retorts with too high a degree of moisture.

Other mechanical defects revealed themselves from time to time, but all are quite capable of explanation and perfection. The plates acted exactly as was expected. The collapsing, which is effected by a mechanical device actuated from outside the retorts, has acted with precision, and allows of the discharge of the carbonised material with almost unfailing regularity.

The main factor which has in the past obstructed the progress of low temperature carbonisation would appaer to have been entirely solved. The yield of tar oils has even exceeded anticipation.

During the period a mechanical defect arose which allowed of a very important investigation. One of a pair of the cast-iron plates broke away from its fastening and had to be replaced. This allowed of an examination of the plate, which had been under heat for some three weeks. Its condition was perfect, and there is little doubt that such plates will endure low temperature heats for a long period without oxidisation. The mechanical defect which allowed of this accident was easily remedied.

So much for the retort and its discharge, both of Coalite and by-products.

A second ingenious addition had also been introduced. In many of the former plants the Coalite on discharge was treated much in the same way as metallurgical coke and quenched in the open. This not only gave the material a bad appearance, but led to the formation of a great deal of breeze. In the present design this has been entirely obviated. The Coalite is discharged into an enclosed cooler surrounded by water, and after a due period the cooler itself is emptied, when the Coalite is found to be in a hard, compact form, containing not more than 5 per cent of breeze. So durable is the material produced, that it suffers very little in transport, and several hundreds of tons have been transported long distarnces, notably to London, without suffering any ill effect.

At an early period in the carbonisation it was found that it would be an advantage, not only mechanically, but financially, to mix the more expensive caking slacks, which form a binder for the whole material, with a proportion of non-caking slack, which often is a material of very much lower value. The proportion has been followed, until to-day 70 per cent. of non-caking slack is being used. I have little doubt that practically all the Yorkshire and Derbyshire coal slacks could be used by themselves, but on the financial side it is highly desirable to mix. In a few instances it is necessary to do so.

By-Products.

The by-products of low temperature carbonisation have been well known for many years, but mainly on a laboratory scale, as there has not been any large quantity available for commercial tests. It is perfectly clear that they contain, primarily, a rich gas of high B.T.U. value. The motor spirits are said to amount to about 3 gallons, of a specific gravity which would apparently place them somewhere between petrol and benzol.

The tar oil, as a whole, burns readily. It can be fractionated into Diesel oil, lubricating oil, and cresylics, all having a high potential value. On distillation, apparently 50 per cent of the tar oil yields will be pitch, which in itself is more than likely to contain material of high commercial value. Ten tons of tar oils are now being fractionated at a high temperature tar distillery, and the results will shortly be available, but as it took many years of careful research to determine the values of high temperature tar, it is too much to expect that low temperature tar oils have as yet been fully analysed.

A leading Institute of Technology, dealing with the commercial aspect of the value of tar and tar oils, has expressed a desire to carry out a series of commercial and technical experiments, now that large quantities are likely to be available.

Engineers' Report.

Your engineers have been engaged upon furnishing a report which is now available, and as I have followed its preparation closely from week to week it is not difficult for me to give you my general comments upon it. From what I have already said, you will gather that my own independent observations support, in so far as they have gone, everything of the same character mentioned in your engineers' report.

One of the most interesting portions of the report, as it affects your immediate and future developments, is their estimate of cost, which they give in their Exhibits No. 3 and No. 5 (these Exhibits are given in a balance sheet).

On the Expenditure side, in Exhibit No. 3, one figure of the highest importance is the price at which this side of the balance sheet should be debited for slack. This figure I have always though of as the "X" of the whole calculation, but it here taken at the high figure of 12s. 6d., which by no means represents the figure which a colliery company establishing a low temperature carbonisation plant would debit to expenditure. There are countries even to-day where these slacks are practically given away, and yet such slacks can be converted into the most highly-priced coal —domestic fuel—sold in London at 60s., and even more. It is quite equal to anthracite, which is sold at even a higher figure.

The cost of carbonisation would appear to be reasonable and quite comparable with such costs in high temperature plants. Such a comparison, however, is misleading. Owing to the low temperature utilised and to other factors, the cost should be lower in your plants.

On the Revenue side, Coalite is taken at 50s. per ton at the works. This is an "X" figure again, depending upon the market value of coal, and it would appear reasonable in the present state of trade for domestic fuels, more particularly when it is realised that Coalite has a radiant value for domestic purposes quite 30 per cent better than the best coal, and this is borne out by Government experiments.

The tar oils have been given a value of 6d.; a conesrvative figure, but one which it is desirable to adopt in such a balance sheet.

Only 1 gallon of benzol is credited, that which comes off with the gas.

Exhibit No. 5 has been prepared to show the effects of a reduction in the price of coal, etc., to figures approaching more normal conditions.

I have followed very closely the preparation of these costs, which have been made out for a plant

carbonising 100 tons of coal per day as against the present small battery of 20 retorts with its 30 tons a day (necessarily using a considerable amount of manual labour), and they would appear to be fair and reasonable.

Conclusion.

I am persuaded that the working of the battery of twenty retorts established at Barugh, continuously and progressively up-to-date, is not only a great step in advance in low temperature carbonisation, but has provided all the data necessary on a commercial scale to warrant your placing the information you now have available before any interested countries or enterprises. It has provided the certainty of the manufacture from slacks of a smokeless transportable fuel of even a higher value than the best domestic coal, and this product alone, in a balance sheet where slack is debited at its proper value, would yield a handsome return, the gases and oils remaining as a factor of safety.

But there are other and very important aspects of low temperature carbonisation which have come out very prominently during the success of this battery. I refer here to its use as an industrial fuel.

The lines of investigation adopted for this purpose have been clearly indicated by your engineers and very promising developments may be witnessed at an early date.

The whole industry, if developed on the lines which you have initiated, would appear to be one of paramount national importance. It may, with the least interference in the proper standard of wages, lead towards the greatest necessity of the country—a cheap standard fuel, domestic or industrial—incidentally smokeless, thus, not only assisting the gradual revival of industry, but also improving the condition of our atmosphere and the health of our people.

Coal is the one great asset which allows of an excess of population beyond the natural feeding capacity of our country on these small islands. If used rationally, it is of much more importance to the British people than the discovery of any other mineral.

Is it too much to hope that when it is fully realised that such a development will only be ancillary to the other great fuel and power industries of the country, that these interests will be the first to come forward and recognise that we may be on the verge of a new era in the use of our most vital asset?

THE AIMS AND BOUNDARIES OF PHYSIOLOGY.*

By Sir WALTER M. FLETCHER, K.B.E., M.D. Sc.D., F.R.S

(Concluded from p. 271)

MEANWHILE, the chemical structore, no less than the material form, of the body was being explored, and here, too, progress followed the path of nalysis, ever more refined and complete. Just as old notions of "humours" of the body had been resolved into varieties of cell activity, so the vague chemical ideas conveyed in the words "protoplasm" or "metabolism" received precision by expression in terms of colloidal systems or of associated enzymes or catalysts in appropriate positions, effecting chemical changes of recognisable type among substances of relative simplicity.

Along these lines of analysis rapid progress has been made, but it is to be observed that it has been in great part along diverging lines. The tendency has been centrifugal, or, to use a biological simile, the growth of physiology has led to fissiparous habit. Pursuit of knowledge by particular technical methods has led to specialism; men have reached points far distant along branches of inquiry that at first grew together from the stem. The very development of new technical methods may by itself lead unavoidably to separatism, for the microscope and test-tube may hesr be used in rooms widely different in equipment and often far separated in space. So have grown up new-named sciences within a science, and the histologist or cytologist, the neurologist, the pharmacologist, the biochemist—each carrying off, so to speak, his part of the subject—may be found to be incurring the dangers or even paying the penalties of schism.

Step by step, however, with this progress in analysis, a continual advance towards synthesis has accompanied it as new truths have been unfolded to the investigator. Here, as in other fields, the conception that the whole is the same as the sum of its parts is either meaningless, or, if it have any meaning, is untrue. Fresh reinforcements have steadily come to the idea that the animal body is not to be rightly considered as a patchwork of the activities of its parts, but that the organism itself as a whole is the true physiological unit. In this conception the functions of the organs and of their own cellular subdivisions can only find due expression in relation to each other and to the functions of the whole. Just in proportion as analysis has proceeded with ever greater refinement to trace in terms of physics or chemistry the nature of given organic or cellular phenomena, the analysis itself is found to be pointing to new relationships between part and part of which the meaning is bound up in the unity of the organism.

Of this continued absorption of analytic data into synthetic conception, this interweaving of increasingly manifest diversities into an increasingly emergent unity, illustration can be found in many directions. The name "hormone" has been given to chemical products of particular organs which pass by way of the blood to stimulate another organ or other organs of the body to changes in activity. This mode of chemical regulation by messenger, so to speak, is superadded to the more rapid method of regulation by nervous impulse through the nervous system: and already many beautiful examples of delicate interplay and co-ordination have been discovered between the two kinds of regulation. In its earlier phases the knowledge of these messengers gave us a picture of relatively simple, though wonderfully adjusted acts of chemical regulation. As analysis of the hormonic exchanges of other glands and tissues of the body has proceeded, however, a system of interplay and reciprocal function of increasing complexity has been revealed by later studies. Our knowledge of this is still young and quite rudimentary, but at every fresh step in this advance it becomes more evident that the multiplying facts can only be resumed by a conception

*Address delivered before Section I, British Association (Edinburgh Meeting).

of the whole organism as a unit of which the parts exist to preserve the integrity and "normality."

In the study of the nervous system, again, new methods of observation and analysis have given us during the past half-century immense additions to our knowledge of the intricate fabrics of the brain and spinal cord and of the functions of the various systems of fibres and cells. The content of our knowledge of these must be tenfold that which was known fifty years ago. Here again, as investigation has gone forward, and as analysis has proceeded by methods so special and so refined that neurologists work, as it were, in a field of their own, it has proceeded only to reveal ever more and more clearly what Sherrington, one of the chief pioneers in this analysis, has himself called the "integrative" action of the nervous system. The fabric of nerve cell and fibre, whether we trace its history from the lower to the higher animals, or whether we trace its complexity in the individual, is revealed to us as a series of superimposed controlling systems whose structural relations find intelligible expression only in terms of functions, and of functions of the animal as a whole.

Is the same return to synthetic conceptions to be found as a result of analysis of the biochemist? His work has brought much simplification to our notions of the chemistry of the body. We have learned that in the exchanges within the living cell we are not necessarily, or indeed probably, dealing with molecules of a complexity unknown outside the living body; we do not now think as formerly of substances being worked up through successive stages of elaboration into a living molecule—a molecule of "protoplasm" of mystical complexity—or of other substances reappearing as the result of incessant degradation of parts of the living molecule. Analysis has shown already that many characteristic cell-changes turn upon relatively simple reactions of a kind familiar in chemistry between known and relatively simple substances. How much further will this analysis proceed? No doubt many of the typical functions of particular kinds of cell will become expressible in a set of chemical formulæ, and every simplification attained by the biochemist in terms of known chemical or physical law will be a notable gain. Yet even now we can feel assured that the analyses of the biochemist bring with them new emphasis upon the essential unity of the whole organism. Let me give but one illustration of this. In the studies of immunity from disease it had long been known that substances which to a chemist would appear to be identical could be sharply distinguished in the most decisive way by biological reactions. Tiny fragments of a small blood-clot can be made thus to declare whether they come from a man or from what other animal, when no chemist would have dreamed of finding a distinction. Dudley and Woodman have lately been able, however, to bring biochemistry within the range of this biological delicacy of discrimination, and have shown a subtle difference in the chemical architectures of the caseins derived respectively from the milk of a cow and of a sheep. More recently the two modes of analysis have been brought side by side. Similar cells in similar organs of the two not widely dissimilar birds, the hen and the duck, secrete layers of egg-albumin during the completion of that wonderful structure, the egg. From the "white" of each egg can be prepared apparently identical albumins, and in a pure crystalline form. This albumin is built up in each case from simple materials—amino-acids—derived from the food, and we should naturally expect a close similarity between the two kinds of resulting albumin, that in the hen's egg and that in the duck's. The most refined methods of ordinary chemical examination show us, indeed, that the two are chemically identical and indistinguishable, containing on analysis the same amounts of the same varieties of amino-acids. But Dakin has lately succeeded in tracing a difference between the two albumins, exhibited only as partial differences in the order or pattern in which some of the constituent amino-acids are linked together in the structure of the albumin molecule. By using a physiological test, Dale, at the same time, has been able to show a decisive and even dramatic difference between the qualities of the two albumins so near to chemical identity. By using the "anaphylactic" reaction of the organic tissue from an animal "sensitised" against hen albumin, he has found that a suitable application of hen egg-albumin will produce a decisive response, while an exactly similar dose of duck egg-albumin will produce no effect whatever; and so *vice versa*. Here, then, is some authentic stamp of unknown kind imposed uniformly upon the parts of the organism of a given species, even upon the molecules of the albuminous coating of its egg. We are brought sharply back from the relative simplicities of chemical analysis to consider this supra-chemical impress of specific pattern, a phenomenon which can have no meaning that is not drawn from a conception of the organism as a whole.

It would be impossible here, and quite unnecessary for the present purpose, to do more than refer finally to the beautiful researches of recent years upon the modes of regulation of breathing, upon the gas exchanges of the blood, and upon the associated activities of other organs, and especially of the kidney, which have brought such ample support and illustration to the doctrine first clearly taught by Claude Bernard, namely, that the different mechanisms of the body, various as they are, have their single object in "preserving constant the conditions of life in the internal environment." These regulative functions in particular have been fully discussed by Dr. Haldane in a recent notable essay, and he has shown how, as their chemical analysis has proceeded and observations have been collected by physiological methods, themselves of a delicacy often far exceeding those of present physical and chemical methods, it has become more and more necessary to express the facts in terms of an organic unity. "The physical and chemical picture is entirely obliterated by the picture of organism." These considerations are full of interest, of course, in their relation to the rival mechanistic and vitalistic theories that have been advanced for the explanation of living processes. Here, however, I refer to this synthetic tendency of modern physiology because of its practical bearing upon the present development of the subject in the universities and the medical schools. As the preliminary analyses of the functions have been, as we

have seen, centrifugal and fissiparous in their tendencies, so the accompanying and inevitable synthesis, resuming analytical data within the notion of organism, has been centripetal and conjugative. It is this bond of organic unity which must sooner or later serve to bring together the scattered workers in different fields of analysis. It is this conception of the organism, moreover, which must maintain physiology as a great primary branch of study—the study of the living organism.

If physiology remains as a free subject of university study, we need not have serious fear that the fissiparous, centrifugal tendencies already noticed will be dangerous or crippling. Ludwig organised his physiology teaching at Leipzig in 1846 under the three main divisions of histology, experimental work, and physiological chemistry. In the English revival that we have earlier sketched, this grouping, largely under the influence of Foster, was maintained not only at Cambridge, but at other centres here and in America. As years have passed, however, there has been an increasing tendency here to follow what is commonly done in other countries, and to place histology with anatomy. In my personal view, physiology cannot proceed without perpetual use of the microscope, and yet anatomy must be dead without histology. I should hope to see histology the well-worn bridge of union between the two subjects, just as, I think, we should look to cytology and the study of cell development to offer active points of growing union between physiology and the sciences of animal and plant morphology. These and other questions of detailed organisation will, I hope, be explored fully in the discussion for which we are hoping to-day. With time also has come a great development of biochemistry, and this, if only from the structural necessities of its laboratory technique, is tending more and more to set up house for itself. This, too, is to be a matter for fuller discussion presently We may perhaps hope to see in biochemistry as it grows not only a common meeting-ground and an unfailing source of new inspiration for physiologists and pathologists alike, but also a pathway by which organic chemistry may be led towards the study of living matter. Few organic chemists in this country, though more in America, have been led by that path till now, and yet we must believe that biochemistry has perhaps even more to give to organic chemistry, as we now know it, than it has to gain. A study of organic compounds in a spirit of detachment from the living processes which gave them birth must surely lead often to mere virtuosity in the laboratory transformations of chemical structure, and I venture very timidly to think that many signs point to the near approach of a time when organic chemistry will feel the need of fresh inspiration coming from the intricate laboratory of the living cell In a university the separation of laboratories, which must be guided solely by convenience, as convenience is dictated by necessary differences in equipment and technique, may be easily transcended by the free communication of workers in different branches. Intellectual association and close co-operation, and especially within a university, seem inevitable, as we have seen, because of the converging approach of diverse workers in common reference to the conception of organic unity. There can be no boundaries to physiology narrower than the limits of the study of the whole organism and the balanced regulation of its living parts.

I would venture here, however, to point to some dangers by which the sound development of physiology seems to be threatened, that spring from its necessarily close association with medical education, dangers eminent in the present stage of rapid growth in medical studies both here and, even more obviously, in America. Historically, physiology may be said to have been born of medicine, but it has sanctions and a strength quite independent of the great services it has rendered and has still to render to the material good of mankind through medicine, and, in a less, though in no insignificant degree, to agriculture. We may recall that chemistry, too, was almost equally born of medicine; medicine, at least, was the foster-mother and long the nurse of chemistry. Lyon Playfair, in his inaugural address of 1858, in this very place, said, nevertheless, that "chemistry in her period of youth, full of bloom and promise, was forced into a premature and ill-assorted union with medicine." We can now look back and see that chemistry, in becoming free of medicine, and in becoming a great independent branch of learning, has, by the fruits of that freedom, repaid to medicine a thousandfold her early debts of the nursery. So, too, the history of the last half-century, in which physiology has become an independent subject of university study, shows how this freedom has multiplied the gifts which physiology has had it in her power to return to her ancient mother. There can be no dissolving of the ties between one and the other, but we must see to it that these ties are well-adjusted and that there shall be no "ill-assorted union" between the two.

In the rapid growth of medical schools throughout the English-speaking world there are present signs that the essential part which physiology plays in medical education and study may wrongly masquerade as the only service physiology has to give to man, and may appear to fill the measure of her rightful status. In more than one of the great American universities physiology is treated either in theory or in practice as a subject within the Medical Faculty to be housed within the Medical School, yet at the same time not as a subject in the Faculty of Arts or of Science, nor to be studied alone or with other sciences as part of a liberal and non-professional education. It is rare in the United States for physiology to be studied by any but professed medical students, and there is some reason to think that it is becoming rarer in Great Britain than it was a few years ago.

To my mind this tendency is to be deplored It implies a reversal of that growth of physiology in freedom which began half-a-century ago and from which such good fruit has already been gathered. It has two chief evils among its inevitable results. Removed from its position among other university subjects by geographical separation that in some universities amounts to transporation and exile, it is deprived of the kinship and co-operation of the sciences touching its own boundaries—those of zoology, embryology,

and botany, of agriculture, of psychology, of physics and chemistry. Assigned, if not limited, to a place in the medical curriculum, it is apt to be narrowed in its claims and outlook, and to lose not only its proper neighbours, but even parts of itself, whittled away in the organisation of a purely medical programme in the guise of pharmacology, neurology, toxicology, and the like, for which special funds may be available, separate places in the time-table reserved, and independent departments provided. But a second evil strikes more deeply. Any arrangements that give in effect a restriction of physiological studies to medical students alone must be doubly injurious. It is injurious to the general course of education, because it tends to cut away from the other university students the opportunity of possessing themselves, either as a primary or secondary study, of the knowledge and discipline of physiology which has educative value in the highest degree for the cultural or the practical sides of living. And here, secondarily, we may notice the loss to an applied study only less in importance to that of medicine; I mean the science and practice of agriculture. It is injurious, again, to physiology itself, because we know well from reiterated experience how many promising recruits for the future advancement of the subject have been brought to it, often, as it were, by chance, in the course of their university life, attracted to it whether from classical studies or mathematical, or from other branches of natural science. A notable number of the chief leaders in the science of the past and present generation have so been attracted, without any previous thought of medical studies as such, whether these have been added later or not; of these, not a few whose names are well known to us all have never become, in the technical sense, students of medicine at all. They may have lost by this, but should we willingly have lost them?

I hope that what I have earlier said with regard to the great service that physiology has both to give to medicine and to receive from it will acquit me of any charge of desiring less, rather than much more, intimacy and intercourse between them. I believe that no better service can be done for the good of both than to increase their mutual offices and the ties between them. But we must see that, in uniting physiology to medicine, we do not uproot it from that soil in which alone it can abundantly flourish and bear fruit, the environment of a university with all that connotes If there be any serious doubt of the reality of the dangers I have indicated, I would point to the dearth of men fitted to promote and teach the subject among those coming from the schools in which physiology is regarded as a medical study and no more, and is not given its full university status. In the United States at present there is a grave and admitted dearth of suitable candidates for chairs of physiology, in spite of the remarkable work which has been done there in recent years and the fine material equipment in general available. I venture to offer my conviction that the prime cause of this shortage is the absence of the great recruiting possibilities of university life and the undue limitation of physiology to medical students. Men coming to physiology as a "preliminary subject" and nothing more are not likely to think of it as their life-work, but will pass through it not to return.

Let me, in conclusion, point again to the highest of the tasks which physiology, like every other science, has to perform. Its highest and indeed its primary task is to enlarge the vision of man and to enrich his knowledge of truth. The secondary tasks of physiology in finding power through truth, power to diminish pain and to restore health, and to guide to right and prosperous living are happily so beneficient in kind, and already in some degree so fruitfully discharged, that it is not easy, or indeed common, to keep in mind that great and primary aim. Right thinking in this respect is the only constant guide to right action in all the practical questions which confront us now in our discussion of the position and the future of this science. "Man does not live by bread alone": and we shall find—we have already abundantly found in experience—that it is only through the seeking of wisdom first that power to increase the comfort and convenience of life is most fully to be won. The practical services of inquiry have been easy for all to see. Men have come readily to think of physiology as the handmaid of medicine and as nothing more. Of late years we who follow the study of living things have not had interpreters to make plain to men at large the interest and beauty of the additions to revealed truth which have been coming from the work of the investigator. There are very few among the onlookers who have seen, or who can bring others to see, those clearer visions of the consummate beauty which are being revealed in the study of the body, visions as remote from the actual figments daily painted for us by our sense organs as are the newest visions of the physical world, yet appealing as strongly to the intellectual and æsthetic emotions. Few hold the quest for natural knowledge in right relation to other activities of the mind; few see it not merely and not in chief as a useful pursuit of power, but in its essence as a pursuit of truth.

That knowledge of natural truth and of the changing pattern of our ideas of the natural world should be an unusual or quite subordinate part of a cultural equipment, in this and in recent generations, may be due to lack of interpreters, but it is due also to convention and educational habit, and these, perhaps, combine in special degree to shut out from the world of general culture the revelations of intricate beauty in the living body of man. Ancient and mistaken theological conceptions filtering through the Victorian age have tended to degrade the dignity and marvel of the body. Generations that have been nurtured upon narrowed classical studies have so far forgotten the spirit of Greece as to ignore the universal beauty of truth; it has been thought vulgar not to know the verbal details of an old mythology, but hardly respectable not to be ignorant of the elementary laws of life and of the unseen beauties of the body unfolded in modern study. So have many submitted to he enchained in ignorance and superstition as to vital matters of reality, victims of every passing charlatan. Out of this loss of instruction in the beauties and wonders of living substance, as they are becoming known, must come great loss of possible happiness, and indeed there come, too, a loss of

dignity, for we may fitly apply the rebuke of Robert Boyle, much more deserved now than in his darker century, who held it to be "highly dishonourable for a Reasonable Soul to live in so Divinely built a Mansion as the Body she resides in, altogether unacquainted with the exquisite Structure of it."

Meanwhile the workers will proceed in their quest for further truth, caring little if, for the time being, other eyes are blind to its beauty. They will still be lured by it as all eager minds have been lured before; some will confess the attraction of a call for help in human need and suffering, some will claim austerely that they follow only the bidding of a curiosity of mind, and some perhaps may work for fame. But, whether they know it or not, the effective lure that Nature holds out to those of her followers who have it within them to respond to it, and so to reach new knowledge, is a quickening hint of further beauty to be unfolded in further truth. Whether they know it or not, they might make the same Confession as that of St. Augustine: "And I replied unto all those things which encompass the door of my flesh, 'Ye have told me of my God, that ye are not He: tell me something of Him.' And they cried, all with a great voice, 'He made us.' My questioning them was my mind's desire, and their Beauty was their answer."

IMPERIAL WAR RELIEF FUND.

Letter to Graduate Members of the Universities of Great Britain and Ireland.

Many men distinguished in letters and science are suffering great privation in Austria to-day, and the present condition of student life is a matter of grave concern for the future welfare of Europe. It is the problem presented by this serious situation that called into activity the Universities' Committee, at the instigation of Lord Robert Cecil. This Committee has appealed to the Universities of Great Britain and Ireland to come to the assistance of the Professors and Undergraduates in the war-stricken areas of Europe. The British Universities are responding generously; the sum of £1 per head per student is being gradually raised, giving to date a total of £32,000; this has been done mainly by student effort. The money is being spent in a carefully organised plan for the relief of the most destitute students in the Universities of Austria, Hungary, Poland, Czecho-Slovakia, &c., and in giving a certain amount of food and clothing to the Professors and Lecturers of the Austrian Universities.

The plea for help for Senior Members of the Universities of Austria has not met with such a wide response as the plea to students for students. This we feel sure is partly due to a feeling that such small gifts as Graduate Members can afford to give may be of insignificant value. We are, however, in a position to point out that any sum subscribed is valuable. The average Viennese Professor, with wife and children, draws but the equivalent of £40 to £60 per year to maintain himself and his family. From the Armistice to the end of last year one-tenth of the Professors and Lecturers of Austria died, largely as a result of want, starvation, and consequent disease. We feel that no further comment is necessary.

The Universities' Committee, whose appeal to students on behalf of students has received such an encouraging response, is asking an equal effort on the part of men of learning in Great Britain and Ireland in the work of relieving the distressed Senior Members of sister Universities. Men who are famous throughout the civilised world, Exner, Tchermak, von Lang, Palisa, Strygowski, Wilhelm, Klein, Fuchs, Fried, Ebner, Charlemont, Lorenz-Liburnau, and many others, are finding very great difficulty in carrying on their work. If every man and woman who has had the privilege of studying in this country would give £1 1s., the staffs of the Austrian Universities would be at least sure of adequate nourishment for themselves and their families.

(*Signed*) William Bragg, Bryce, A. S. Eddington, Richard A. Gregory, Haldane of Cloan, Frederic G. Kenyon, Walter Lock, Donald Macalister, Charles J. Martin, Henry A. Miers, Gilbert Murray, E. Rutherford, M. E. Sadler, Arthur Schuster, Napier Shaw, A. E. Shipley, George Adam Smith, Ernest H. Starling, J. J. Thomson.

Since the above signatures to this appeal were given, facts as to the conditions obtaining among the men of science and learning in Russia have been brought to our attention. Between 1914 and 1920, 30,000 doctors died through war and pestilence. The need for doctors, scientific men, engineers, agriculturists, &c., is vital to the country. Through seven years of war and revolution, with almost complete severance from Western Europe, Russia has been reduced to a position dangerous to civilisation. Famine of an intensity unparalleled in human record has devastated the country. The American Relief Administration and other funds are bending all their energies on trying to save the children. The Universities' Committee, in co-operation with the British Committee for Aiding Men of Letters and Science in Russia, hope also, with your assistance, to relieve some of the most acute distress obtaining in the Universities of Russia.

Cheques should be made payable to the Hon. Treasurer, Universities' Committee, and sent to the Organising Secretary, at Fishmongers' Hall, London Bridge, E.C.4.

Eleonora Iredale, *Organising Secretary.*

NOTES.

Royal Institution.—The Ninety-Sixth Christmas Course of Juvenile Lectures, founded at the Royal Institution in 1826 by Michael Faraday, will be delivered this year by Prof. J. A. Fleming, F.R.S., on "Electric Waves and Wireless Telephony." The Lectures, which will be experimentally illustrated, will be given on the following days at 3 o'clock: Thursday, December 29, "Surface Waves on Liquids"; December 31, "Waves in Air"; January 3, "The Telephone"; January 5, "Electric Oscillations"; January 7, "Electric Waves,"; and January 10, "Wireless Telephony."

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THE OPTICAL SOCIETY.—In addition to its ordinary programme, the Optical Society has arranged a series of special meetings to be devoted to subjects dealing with the evolution and development of various types of optical instruments. The Science Museum, Kensington, possesses a most interesting, and in many respects, unique collection of such instruments, with the characteristics of which instrument makers and users might well be more familiar. By arrangement with the Museum authorities, these instruments will be available at the meetings for purposes of illustration and demonstration. The first meeting of the series will be held at the Imperial College of Science and Technology, on Thursday, Nov. 24, 1921, at 7.30 p.m., when Prof. F. J. Cheshire, C.B.E., will deal with "Polarising Apparatus." Other subjects to be discussed at future meetings include "Microscopes" (Prof. A. Pollard), "Telescopes" (Mr. D. Baxendall), "Astronomical and Surveying Instruments" (Mr. L. C. Martin).

MEETINGS FOR THE WEEK

Monday, November 28.

Royal Society of Arts, 8. (Cantor Lecture). "Processes of Engraving and Etching," by Arthur M. Hind.

Faraday Society, 8. "The Effect of Cold Work on Commercial Cadmium," by J. Neill Greenwood. "Reaction between Cathodic Hydrogen and Nitrogen at High Pressures," by J. N. Pring and E. O. Ransome. "The Electrolysis of Aqueous Solutions of Alkaline Nitrites with a Lead Anode and an Electrometric Determination of the Constitution of the Complex Anion Formed," by F. H. Jeffery. "An Inhibition Period in the Separation of an Emulsion," by T. C. Nugent. "Induced Reactions and Negative Catalysis," by N. R. Dhar and N. N. Mittra. Dr. S. Judd Lewis and Miss F. M. Wood will exhibit and describe "A New Adjustable Thermostat for all Temperatures between 0 and 100 deg. Cent."

Wednesday, November 30.

Royal Society of Arts, 8. "The Preservation of Stone," by Sir Frank Baines.

Thursday, December 1.

Institution of Electrical Engineers, 6. "The Cyc Arc Process of Automatic Electric Welding," by L. J. Steele and H. Martin.

NOTICES.

EDITORIAL.—All Literary communications and Books, Chemical Apparatus, &c., for review or notice to be addressed to the EDITOR.

SUBSCRIPTIONS, £1 12s. per annum, payable in advance should be addressed to the MANAGER.

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ROYAL SOCIETY—GOVERNMENT GRANT FOR SCIENTIFIC INVESTIGATIONS.

APPLICATIONS for the year 1922 must be received at the Offices of the Royal Society not later than January 1st next, and must be made on printed forms to be obtained from the Clerk to the Government Grant Committee, Royal Society, Burlington House, London, W.1.

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THE PRESENT POSITION OF THE THEORY OF DESCENT, IN RELATION TO THE EARLY HISTORY OF PLANTS.*

By H. D. SCOTT, LL.D., F.R.S.

It has long been evident that all those ideas of evolution in which the older generation of naturalists grew up have been disturbed, or, indeed, transformed, since the re-discovery of Mendel's work and the consequent development of the new science of Genetics. Not only is the "omnipotence of Natural Selection" gravely impugned, but variation itself, the foundation on which the Darwinian theory seemed to rest so securely, is now in question.

The small variations, on which the Natural Selectionist relied so much, have proved, for the most part, to be merely fluctuations, oscillating about a mean, and therefore incapable of giving rise to permanent new types. The well-established varieties of the Darwinian, such as the countless forms of *Erophila verna*, are now interpreted as elementary species, no less stable than Linnean species, and of equally unknown origin. The mutations of De Vries, though still accepted at their face value by some biologists, are suspected by others of being nothing more than Mendelian segregates, the product of previous crossings; opinion on this subject is in a state of flux. In fact, it is clear that we know astonishingly little about variation.

My friend, Dr. Lotsy, indeed, proposes to dispense with variation altogether, and to find the true origin of species in Mendelian segregation; inheritable variability, he believes, does not exist; new species, on his bold hypothesis, arise by crossing, and so, as he points out, we may have an evolution, though species remain constant. Thus everything apparently new depends on a re-combination of factors already present in the parents. "The cause of evolution lies in the interaction of two gametes of different constitution."

I am aware that very surprising results have been obtained by crossing. Nothing could well have been more striking than the series of *Antirrhinum* segregates which Dr. Lotsy showed us some years ago at a meeting of the Linnean Society. And now we hear of an apetalous *Lychnis* produced by the crossing of normally petaloid races. We do not know yet to what extent that sort of thing goes on in Nature, or what chance such segregates have of surviving. Still, if one may judge by Dr. Lotsy's experimental results, ample material for Natural Selection to work on might be provided in this way (see Dr. Lotsy's book, "Evolution by Means of Hybridisation, The Hague, 1916).

Dr. Lotsy's theory that new species originate by Mendelian segregation, if true, would have the advantage that it would make quite plain the meaning of sexual reproduction. Hitherto there has been a good deal of doubt; some authorities have held that sexual reproduction stimulated, others that it checked variation. But, if we eliminate variation, and rely solely on the products of crossing, we get a clear view—"species, as well as individuals, have two parents"; sexual reproduction can alone provide adequate material for new forms, and can provide it in unbounded variety.

Again, though Dr. Lotsy himself is far from sanguine on this point, the crossing theory might be helpful to the evolutionary morphologist, for breeding is open to unlimited experiment, and we might hope to learn what kinds of change in organisms are to be expected. For example, the *Lychnis* experiment shows how easily a petaloid race may become apetalous. Such results might ultimately be a great help in unravelling the course of evolution in the past. We should gain an idea of the transformations which might actually have taken place, excluding those which were out of the question. At present all speculation on the nature of past changes is in the air, for variation itself is only an hypothesis, and we have to decide, quite arbitrarily, what kind of variations we think may probably have occurred in the course of descent. One need only recall the various theories of the origin of the seed from the megasporangium to realise how arbitrary such speculations are.

But, while recognising certain advantages in the theory of the origin of species by crossing, it is not for me to pronounce any opinion as to its truth. It is only the present position of the question that concerns us to-day. We shall hope to hear a statement of Dr. Lotsy's views from his own lips.

Some modern geneticists believe that there is evidence for mutation by the loss of factors, apart from the effects of crossing. Dr. Lotsy considers that such changes, if proved, can afford no explanation of progressive evolution. "Evolution by a process of repeated losses is inconceivable." It has, however, been pointed out by Dr. Agnes Arber, in her recent admirable book on water-plants, that, on any theory of evolution, "what organisms have ganied in specialisation they have lost in plasticity." She avails herself of a human analogy and says: "The man, though superior to the baby in actual achievement, is inferior to it in the qualities which may be summed up in the word 'promise'," just as the Angiosperm, though its degree of differentiation so greatly exceeds that of the primordial protoplasmic speck, is inferior to it when judged by its power to produce descendants of widely varying types (p. 335).

This is true, but it is not clear that this admitted loss of potentialities is the same thing as the loss of factors, in the sense of genetics. For example, if a glabrous variety of Violet really arose as a mutation by loss of the factor for hairiness, assuming that such a loss was permanent, the effect would seem to be a diminution of specialisation, though, no doubt, it might also be interpreted as a loss of potentiality.

Turning for a moment to Darwin's own theory of the origin of species by means of natural selection, the efficacy of the latter, in weeding out the unfit, is, of course, still acknowledged, and some geneticists allow is a considerable rôle. But there is a strong tendency in these days to

* Address delivered before Section K, British Association (Edinburgh Meeting).

admit natural selection, only as a "merely negative force," and as such it has even been dismissed as a "truism." Now Darwin's great book was most certainly not written to enunciate a truism. He regarded natural selection as "the most important, but not the exclusive, means of modification" ("Origin of Species," p. 4). It was the continual selection of the more fit, the "preservation of favoured races," on which he relied, and not the mere obvious elimination of the unfit, and this great idea (so imperfectly understood by many of his contemporaries and successors) he worked out with astonishing power, in the light of the changes which man has produced, with the help of his own artificial selection.

It may be that the theory of natural selection, as Darwin and Wallace understood it, may some day come into its own again; certainly it illuminated, as no other theory has yet done, the great subject of adaptation, which to some of us is, and remains, the chief interest of biology. But in our present total ignorance of variation and doubt as to other means of change, we can form no clear idea of the material on which selection has had to work, and we must let the question rest.

For the moment, at all events, the Darwinian period is past; we can no longer enjoy the comfortable assurance, which once satisfied so many of us, that the main problem had been solved—all is again in the melting-pot. By now, in fact, a new generation has grown up that knows not Darwin.

Yet evolution remains—we cannot get away from it, even if we only hold it as an act of faith, for there is no alternative, and, after all, the evidence of palæontology is unshaken. I have thought it fair to lay stress on the present state of uncertainty in all that concerns the origin of species. On another occasion I even ventured to speak of the return of "pre-Darwinian chaos." But out of this chaos doubtless light will come.

Last year we had a joint discussion on Genetics and Palæontology; among many good speeches, I specially remember a remark by Miss Saunders, our then President, that Mendelism is a theory of heredity, not of evolution—a caution not unneeded, though as the crossing hypothesis shows, the connection between the two conceptions may prove to be a very close one.

Genetics is rendering the greatest service to biology generally in ensuring that organisms shall be thought of as races, not as isolated individuals, mere chemical and physical complexes, at the mercy of the environment. The whole tendency of modern work is to show that in living things heredity is supreme. An organism is what it is by virtue of the constitution of the germ-plasm derived from its parents. As Dr. Church has said in one of his recent Botanical Memoirs: "The individual is no longer to be regarded as an isolated unit, or a casual creation, but is the present representative of a 'race'." That is to say, the individual is not, as short-sighted chemical physiologists tend to believe, a mere physical mechanism, the creature of the external environment to which it passively responds! but it is the living presentation of a continuous line of organism, successful since living, or a "race" leading back as the expression of continued response to very similar, but not necessarily identical, environment, in unbroken plasmatic continuity, over a period of time which, in terms of ultimate cytological history, may represent a continuous reaction and record for anything up to such an inconceivable period as two thousand million years." This expresses the case vigorously, whether we accept the time estimate or not. Dr. Church goes on to say that "during this period the more fundamental reactions, as expressed in morphological units of construction, have been established as constants beyond any hope of change" (Form Factors in Coniferæ, Oxford, 1920, p. 22). This last statement is an important one for the palæontologist, for all our attempts to trace descent rest on the assumption that, in a general sense and as regards certain well-established characters, "Like breeds like."

History, then, broadly speaking, is everything. But there is more than one kind of history in biology. First, we have the exact records of the Mendelian from generation to generation, F^1, F^2, and so on; this alone is adequate, but we usually have to be content with something much less. At the other end of the scale there is the fossil history full of gaps and uncertainties of every kind, but always imposing from its vast duration. Then there are intermediate kinds of biological history, such as the imperfect records of the breeding of cultivated plants or domestic animals. These can sometimes now be interpreted in the light of the more exact genetic histories, as Dr. Lotsy will show us in the case of some neglected and misinterpreted observations of Darwin. "Domestication," as he says, "spells segregation, followed by selection and isolation of the desirable segregates." Darwin himself, though necessarily groping in the dark where genetics were involved, yet thought the study of cultivated and domestic races the best clue to the origin of species. If this holds good still, it makes a strong point in favour of the crossing theory of evolution, for the history of cultivated races seems to be largely the history of deliberate or unconscious Mendelian crossings. We may reasonably expect to find a relation between the process of origination of new cultural races and that of new species in Nature.

This suggests the question, what we mean by a "species"—far too difficult a matter to discuss now. Whatever we may think of Darwin's theory, his "Origin of Species" is at any rate a classic, and I believe we cannot do better than continue to use the word in the same sense as Darwin used it—*i.e.*, essentially in the sense of a Linnean species.

Perhaps the best answer to the question "What is a species?" is in the form "*Ranunculus repens*," avoiding all attempts at definition. I know Dr. Lotsy thinks differently, but pure races, whatever else and however important they may be, "are but rarely or never met with in Nature" (Lotsy), and are certainly not *species* in the classical sense in which Darwin used the word; to my mind it seems a pity to go out of our way to change completely the meaning of a familiar term. We can continue to call "pure races" by that name or any more modern equivalent, and "elementary species" may still be called so, or I have no objection to calling them "Jordanons."

In the interests of practical taxonomy they necessarily have to be kept subordinated to Linnean species. There are difficulties enough either way, but they are, as it seems, less if we adopt the conservative course. That many Linnean species are real units of a definite order is generally admitted. Dr. Lotsy himself dwells on their distinctness, which depends on their usually not inter-crossing, and appears to be shown by the fact that among animals members of the same species recognise each other as such and habitually breed together. Such habitual breeding together under natural conditions is perhaps the best test of a species in the Linnean sense. "The units within each Linnean (=species) form an inter-crossing community" (Lotsy). He adds: "Consequently it is Nature itself which groups the individuals to *Linneons*." These "*pairing* communities" have recently been re-christened by Dr. Lotsy "syngameons", a good name to express this aspect of the old species (Lotsy, *La Quintessence de la Théorie du Croisement.* Archives Néerlandaises des Sciences, Sér. III. B., 1917, iii.).

I do not propose in these brief remarks to venture on that well-worn subject the inheritance of acquired characters—*i.e.*, of such characters as are gained during the lifetime of the individual by reaction to the environment. There has always been a strong cross-current of opinion in favour of this belief, especially in our own time, in the form of "unconscious memory", so ably advocated by Samuel Butler and supported by Sir Francis Darwin in his Presidential Address to the British Association at Dublin. Prof. Henslow, as we all know, is a veteran champion of the origin of plant structures by self-adaptation to the environment. On the other hand, some geneticists roundly deny that any inheritance of somatically acquired characters can take place. In any case, the evidence, as it seems, is still too doubtful and inadequate to warrant any conclusion, so, however fascinating such speculations may be, I pass on.

To bring these introductory remarks to a close, we see that while the theory of descent or evolution is undisputed, we really know nothing certain as to the way in which new forms have arisen from old. During the reign of Darwinism we commonly assumed that this had happened by the continual selection of small variations, and we are no longer in a position to make any such assumption.

We have been told on high authority that "as long as we do not know how *Primula obconica* produced its abundant new forms it is no time to discuss the origin of the Mollusca or of Dicotyledons" (Bateson). Yet this is just the kind of speculation in which a palæontologist is apt to indulge, and if kept off it he would feel that his occupation was gone! However, so long as we may believe, as already said, that, on the whole, like breeds like, that grapes do not spring from thorns, or figs from thistles, there is perhaps still sufficient basis for some attempt to interpret the past history of plants in terms of descent. But certainly we have learnt greater caution, and we must be careful not to go far beyond our facts, and, in particular, to avoid elaborate derivations of one type of structure from another where the supposed transitional forms have but a purely subjective existence; we have realised the difficulty of tracing homologies. We may still be allowed to seek affinities, even where we cannot trace descent. And though we may sometimes fo a little beyond our tether and give rein to bolder speculations, there is no harm done so long as we know what we are doing, and there may be even some good in such flights if our scientific use of the imagination serves to give life to the dry bones of bare description. On this subject I am somewhat more optimistic than Dr. Lotsy, who, abandoning his "Stammesgeschichte" point of view, has dismissed all attempts at phyligenetic reconstruction as "fantastic."

There are some questions of the highest interest that at present can scarcely be approached in any other but a speculative way. Within the last year or two, new points of view have thus been opened out. For example, Dr. Church's able essay on "Thalassiophyta and the sub-aerial transmigration" has brought vividly before us the great change from marine to terrestial life.

The origin of a land flora had, of course, been discussed with much ability before, but rather as incidental to a morphological theory. Dr. Church puts the actual conquest of the land in the foreground. We watch the land slowly rising toward the surface of the primeval ocean, the rooted sea-weeds succeeding the free-swimming plankton, and then the continents slowly emerging and the drama of the transmigration as the plants of the rock-pools and shallows fit themselves step by step for sub-aerial life when the dry land appears. It is a striking picture that is thus displayed to our view —whether in all respects a faithful one is another question; we must not expect impossibilities. The doubts which have been raised relate first to the assumed world-wide ocean, which seems not to be generally accepted by geologists. If continental ridges existed from the first (*i.e.*, from the original condensation of watery vapour to form seas), the colonisation of the land may have followed other lines and have happened repeatedly. Perhaps, after all, that would not greatly affect the botanical aspects of the transmigration.

The other difficulty is, however, a botanical one. Dr. Church looks at the whole problem from the sea-weed point of view, and it is well he does, for sea-weeds have been badly neglected, especially by some of the great continental morphologists, who used to lead our speculative flights. Dr. Church is much impressed by the high organisation of many sea-weeds, especially in the living marine flora, by that of the Brown Algæ. Here we find well-differentiated leaves, special reproductive shoots, extremely efficient holdfast roots, and sometimes a definite alternation of generations, while, on the anatomical side, we meet with true parenchymatous tissues, a well-developed phloëm and secondary growth in thickness. There is, in fact, in many respects, an anticipation of, or an analogy with important features which characterise the higher plants of the land.

Dr. Church believes that the chief morphological characters of the land flora were first outlined in the sea; that such characters were not newly assumed after transmigration, but that

they merely represent an adaptation to sub-aerial conditions of a differentiation already attained at the phase of marine phytobenthon (rooted sea-weeds). At the same time it is not suggested that any existing class of sea-weeds can be taken as representing the ancestry of the land flora; the transmigrant races are, as Algæ, extinct—they may have been Green Algæ of a high grade of organisation, on a level now perhaps most nearly represented by the highest of the Brown Seaweeds.

Thus the transmigrants, which were destined to become the parents of the land flora, are pictured as already highly organised and well-differentiated plants, which only needed to provide themselves with absorptive instead of merely anchoring roots, and with a water-conducting system (xylem and stomata) in order to fit themselves for sub-aerial life, while, on the reproductive side, the great change remaining to be accomplished was the adaptation of the spores to transport by air instead of by water.

It is clearly impossible to criticise the theory in detail, for the assumed transmigrants are *ex hypothesi* unknown; we can only form a distant conception of what they were from the analogy of the highest sea-weeds of the present day, which admittedly belong to quite different lines of descent. Dr. Church puts the transmigration so far back (pre-Cambrian) that not much help can be expected from fossils, but to this subject we shall return

Some botanists find a difficulty in accepting the suggestion that plants already elaborately fitted out for a marine life could have survived the transition, however gradual, to a totally different environment. Such thinkers prefer to believe that lower forms may have been more adaptable, and that morphological differentiation had, in a great degree, to start afresh when the land was first invaded. My own sympathies, I may say, are here with Dr. Church, for I have long inclined to the belief that the vascular plants were, in all probability, derived from the higher Thallophytes. The view of the late Prof Lignier, now so widely accepted, that the leaf, at least in the megaphyllous or fern-like vascular plants, was derived from specialised branch-systems of a thallus, assumes, at any rate, that the immediate ancestors possessed a well-developed thallus, such as is now known only among the higher Algæ. The Hepaticæ, as we now know them, clearly do not come into the question, and the Pro-hepatics, which Lignier postulated as early ancestors, have only a theoretical existence, and if they were ever present in the flesh may well have been transmigrant Algæ.

The question now arises, how far have we any evidence from the rocks, which may bear on the transmigration and on the nature of the early land flora? A very few years ago no such evidence was available—such data as we then possessed seemed too obscure to discuss. Quite recent discoveries, especially those from the famous Rhynie Chert-bed, have shown that in early Devonian times certain remarkably simple land-plants existed, which in general configuration were no more advanced than some very ordinary sea-weeds of the present day. At the same time, these plants were obviously fitted for terrestial life, as shown by the presence of a water-conducting tissue and stomata, and by the manifestly air-borne spores. These simplest land-plants are the Rhyniceæ (*Rhynia* and *Hornea*), while the third genus, *Asteroxylon*, was more advanced and further removed from any possible transmigrant type.

My friend Dr. Arber was so impressed by the primitive character of *Rhynia* (the only one of these genera then known) that he boldly called it a Thallophyte, while recognising, in respect of anatomical structure, an intermediate position on the way to Pteridophyta. This is not really very different from the view taken by the investigators themselves, though they call the plants Pteridophytes, which they certainly are, if we go by internal structure rather than external morphology. But if, as Kidston and Lang suggest, the Rhyniaceæ "find their place near the beginning of a current of change from an Alga-like type of plant to the type of the simpler vascular Cryptogams, they must have been very primitive indeed and might even be regarded as fairly representing the true transmigrants which had not long taken to the land. (This view is further developed and expanded in the authors' fourth memoir, which I have had the privilege of reading in MS.).

It is true that the middle Devonian is much too late a period for the original transmigration (I believe there is some evidence for land-animals in the Lower Silurian), but one may argue that some of the transmigrant forms may have survived as late as the Devonian, just as the *Selaginella* type seems to have gone on with little change from the carboniferous to the present time. There must have been many such survivals of earlier forms in the Devonian period, if Arber was right in regarding all the characteristic plants of the *Psilophyton* Flora as "much more probably Thallophyta than Pteridophyta ("Devonian Floras: A Study of the Origin of Cormaphyta," Cambridge, 1921, p. 47). Certainly some of them, apart from the Rhyniaceæ, have an alga-like appearance (*e.g.*, *Pseudosporochnus*) and there is some evidence that such plants also were vascular. There is, in fact, no doubt that the earlier Devonian Flora is turning out to have been on the whole more peculiar and more unlike the higher plants than we realised a few years ago. The early Devonian plants cannot usually be referred to any of the recognised groups of Pteridophytes, and this is not owing to our imperfect knowledge, for it is just in those cases where the plants are most thoroughly known that their unique systematic position is most manifest. Arber called all the plants in question "Procormophyta"—an appropriate name. As Kidston and Lang point out in their later work, the three groups—Pteridophyta, Bryophyta, and Algæ—are brought nearer together by the Rhynie fossils.

And yet there is evidence that about the same period stems with the highly organised structure of Gymnospermous trees already existed. I refer to remains of which *Palæopitys Milleri*, from the Middle Old Red Sandstone of Cromarty, is the type. We need much further investigation of these higher forms of early Devonian vegetation, but we know enough to impose caution on our speculations.

The Rhyniaceæ, at all events, were leafless and rootless plants. In one species of *Rhynia* and in

Hornea the aerial stems are entirely without any appendages, while in the other *Rhynia* there are hemispherical swellings, which have been identified by Arber with certain states of the spines in *Psilophyton*. The emergences of *R. Gwynee-Vaughani* have been interpreted as nascent leaves, but more recent observations, showing their late histological origin, have rendered this hypothesis very doubtful.

In *Asteroxylon*, a higher plant altogether, the stem is clothed with quite distinct leaves, though they are somewhat rudimentary as regards their vascular supply. Have we, in these plants, and others of contemporary date, the first origin of the leaf from a mere non-vascular emergence, or had reduction already been begun, so that in Rhyniaceæ, for example, the leaves were in the act of disappearance? In the former case we should be assisting at the birth of Lignier's phylloids, the microphylls of the Lycopod series, though, as just mentioned, the outgrowths in *Rhynia Gwynne-Vaughani* may have had nothing to do with leaves.

But the opposite view may also be tenable. We have already seen that these plants have been referred both to the Pteridophytes and the Thallophytes; they also show signs of Bryophytic affinities, and I understand that it has even been proposed to include them in the Bryophyta, in which case every possible view will be represented. The *Sphagnum*-like structure of the columellate sporangium or sporogonium of *Hornea* and *Sporogonites* may justify the Bryophytic attribution, and it is then, of course, easy to extend it to *Rhynia*. If we were to adopt this opinion, we should probably have to regard these simple Devonian plants as representing stages in the reduction of the sporophyte to a sporogonium, the leaves being already nearly or quite lost, while the branched thallus was still much in excess of the simple seta of the modern Moss or Hepatic. Naturally we know nothing of the gametphyte, so that the material for comparison is limited. Kidston and Lang, however, have recently pointed out that the presence of spore-tetrads clearly indicates the existence of a gametophyte.

I make no attempt to decide between these views. There can be no reasonable doubt that the Psiliphytales generally represent an earlier phase of Cormophytic life than any of the groups previously recognised. But we must not assume that *all* their characters were primitive. It has been pointed out that the Rhyniaceæ were peat plants, and that the peat-flora is apt to be peculiar. Under such conditions it is not improbable that a certain amount of reduction may have already been undergone, though this is not the view taken by the investigators.

(To be continued.)

THE MICROCHRONOGRAPH.*

By Prof. R. A. SAMPSON, F.R.S.

The instrument described is in actual use at the Royal Observatory, Edinburgh, for registering clock times of any signal accurately to 0·001 sec., for the purpose of examining short-period changes in the relative rates of two clocks, or the lag of a controlled clock, or of one part of a piece of apparatus with respect to another. It has many other applications. The means employed are an adaptation of the oscillograph; this instrument can be so constructed as to be completely free from noxious or variable lag of its own. A detector is placed between the poles of a powerful electro-magnet. This detector consists of a short loop of fine platinoid wire, under tension, and spanned by small plane mirror. The clock signal or other signal being given as an electric current of a few milliampères is recorded photographically on a moving film by help of a minute rotation of the mirror. The rate of motion of the film cannot be trusted for fine measurement over an interval of one second; therefore the standard is taken from an interrupter which cuts off the light falling on the mirror at intervals of approximately 0·1 sec. This interrupter is a simple steel tongue, set in vibration and not maintained in any way, and carrying a wire which occults a slit through which the light passes.

The scale employed can be varied within wide limits. That used most frequently at present gives a motion of the film of about 3·3 cm. per second, with a lateral displacement of 0·13 mm per milliamp., corresponding to a magnification of the movement of the wire loop of the detector by about 1000.

Exhaustive tests have shown that the instrument is completely reliable.

* Read before the British Association (Edinburgh Meeting), Section A.

ULMITE, A CONSTITUENT OF BLACK SANDSTONE.*

By THOMAS STEEL.

At various points along the coast of New South Wales there occur frequent outcrops of a black friable sandstone. The positions of some of these in the Richmond River district are indicated on maps published by the New South Wales Department of Mines (Ann. Rept., 1895, p. 151; 1896, p. 155).

At Tweed Heads a thick bed is exposed on the north bank of the river near the township, from which the sample described in this paper was obtained. There is no igneous rock near the deposit, which is covered by a layer of ordinary sand of varying thickness. Water collected in wells dug in the overlying sand is brown in colour.

The rock is very friable, rubbing readily between the fingers to a sharp sand. On ignition a fragment crumbles to loose sand and becomes white. A portion heated in a glass tube yields water having a strongly acid reaction.

Under the microscope the rock is seen to be built up of worn sandgrains of fairly uniform size, each of which is covered with a thin dark-coloured film resembling a coat of varnish. Gentle friction suffices to remove the coating from the sand grains. On lixiviating the pulverised rock the dark coating can be readily separated and obtained quite free from sand and, when dry, forms a dark brown powder. Microscopically this shows as irregular flakes of vary-

* From the *Proceedings of the Linnean Society*, New South Wales Vol. xlvi, Part II, May 25, 1921.

ing thickness, the inner ones being structureless and of a translucent brown colour, while the thick ones are black and opaque. The translucent flakes do not affect polarised light, and as will be shown, chemical examination proves the substance to consist of humus or humic acid. The powder is readily and completely soluble in caustic potash, soda, or ammonia, forming a clear deep-brown liquid, which, on acidifying with sulphuric or hydrochloric acid, deposits a copious brown flocculent precipitate, leaving the solution moderately coloured. In strong sulphuric acid the dark powder dissolves readily, particularly on slightly warming, forming a clear, very dark-brown solution, which, on being poured into a large volume of water, throws down a copious soft brown precipitate, leaving the solution only slightly coloured. In strong nitric acid, the powder dissolves readily, but no precipitate is produced on dilution witb water nor on neutralisation with alkalies. Even on boiling, the substance is only sparingly soluble in strong hydrochloric acid.

When the precipitate obtained by dilution of the solution in strong sulphuric acid is drained on a filter, the resulting slimy mass is readily soluble in water and also in strong spirit, giving a solution resembling caramel. The water solution obtained in this way, when treated with barium hydrate or carbonate becomes colourless, the substance being carried down along with the barium sulphate. The dark-brown solution obtained by treating a dilute solution of soda or potash with excess of the substance, is readily precipitated with alcohol, the supernatant liquid having still, however, a fairly dark colour. A solution in potash, on neutralisation with sulphuric acid, avoiding excess, remains clear and is precipitated by addition of alcohol. The precipitate may be thoroughly washed with dilute alcohol (Sp. Gr. 0·86), after which it dissolves readily in water, the solution so formed not being precipitated by alcohol, but, if a small amount of potash or soda be added, alcohol produces a copious precipitate, leaving the solution only slightly coloured. The aqueous solution of the alcohol-washed precipitate gives brown precipitates with most metallic salts, precipitation being complete, also with the hydrates and salts of barium, calcium, and strontium, with the alums, and with bromine water. Iodine, tannin, and starch solutions produce no precipitate.

Amongst the few metallic salts which do not cause a precipitate are mercuric chloride and ammoniacal nitrate of silver. The colour is removed by shaking with hydrates of iron and alumina and with litharge, manganese dioxide, animal charcoal, and ordinary soil, previous ignition of the soil making no difference. When shaken with sand the solution is decolourised, the colour, however, being absorbed entirely by the fine clayey portion of the sand, the coarser grains being inert. The same applies to treatment with the black sandstone, after ignition, but if sand or soil is boiled with hydrochloric acid and washed so as to remove soluble mineral matters, the residue is quite inert.

The substance can be salted out of solution with a number of salts, sodium chloride, and sulphate, ammonium sulphate, nitrate and chloride and others, leaving the solution but faintly coloured. From concentrated solutions, acetic acid causes practically complete precipitation in a well curdled form, but from dilute solutions the precipitate is slimy but equally complete.

The barium compound prepared by precipitating the water soluble preparation with baryta water, washing with alcohol, and drying, corrected for associated mineral matter, contains 41·3 per cent. barium oxide.

The pulverised air-dry rock yielded the following figures to proximate analysis:—

Water	1·63
Loss on ignition	8·19
Sand	89·50
Soluble in hydrochloric acid ...	0·68
	100·00

When the coating from the black sandstone is lixiviated until quite free from sand and air-dried, it has the following proximate composition:—

Water at 150° C.	17·3
Loss on ignition	67·6
Mineral	15·1
	100·00

On boiling 0·5 grm. with 50 cc. N/10 caustic soda and titrating back with corresponding sulphuric acid, 24·7 cc. of neutralisation was obtained.

This preparation, after drying at 150° C., calculated free from mineral matter, gave the results below, on ultimate analysis. Humus is known to have a somewhat variable composition according to source and method of preparation. When made from sugar, for instance, ti may be quite free from nitrogen. For comparison I have inserted analyses of humus from a number of sources, references to which are given.

Analyses of Humus Derived from Various Sources.

	(1)	(2)	(3)	(4)
Carbon ...	50·53	57·75	53·42	52·71
Hydrogen ...	5·67	5·43	5·16	3·98
Oxygen ...	43·20	36·02	40·92	41·49
Nitrogen ...	0·60	0·80	0·50	1·82
	100·00	100·00	100·00	100·00

(1) Black sandstone. New South Wales.
(2) Brown peat. Watt's "Dict. Chem.", 1879, viii., p. 649.
(3) Decayed fir wood. *Jour. Chem. Soc.*, 1906, Abs. ii., p. 388.
(4) Decayed oak wood. *Jour Chem. Soc.*, 1906, Abs. ii., p. 388.

A preparation of humus made by treating black soil from Blackheath, N.S. Wales, with potash, and precipitation with sulphuric acid, behaved in all respects in a manner identical with the black sandstone preparation.

I would propose the name Ulmite for this form of humus as found coating sandstone grains.

Samples of black sandstone were supplied to me by Mr. W. S. Dun, of the Department of Mines, from McAuley's lead, Esk River; Iluka, Clarence River; and Sans Souci, near Sydney. They were in all respects similar to my specimen from Tweed Heads.

A similar coating to the above occurs on the rounded grains and pebbles of rock phosphate which constitute the surface "soil," four to six inches in depth, on Ocean Island (*Jour. Soc. Chem. Ind.*, 1921, xl., p. 59T).

THE REACTION OF IRON WITH NITRIC ACID.

By JOSEPH G. BROWN.

In previous papers the theory was advanced that the rate of solution of iron in nitric acid of different density is associated with different chemical reactions. This theory was based upon the study of a voltaic cell having an iron anode and with nitric acid as an electrolyte. In general it was concluded, (1) that the rapid rate which takes place in dilute acid is associated with the formation of ferrous nitrate; (2) that the moderate rate which occurs in acid of intermediate density is associated with a ferrous reaction involving some other product than ferrous nitrate; and (3) that the very slow rate in concentrated acid is associated with a ferric reaction.

The chemical products of this reaction and of the electrolysis of nitric acid were investigated by Freer and Higley in 1899. Veley and Manley measured the electrolytic conductivity of nitric acid in 1898. Young and Hogg measured the reaction rates of the process in 1915.

A consideration of the results of these studies and of the properties of the iron and nitrogen oxides and hydroxides has led to a more detailed theory of the action of iron with nitric acid.

Iron forms three known oxides: ferrous, ferric, and ferroso-ferric; and three hydroxides: ferrous, ferric, and meta-ferric. The hydroxides are amphoteric, *i.e.*, they act either as weak bases or weak acids. This indicates that they ionise either with hydroxyl or hydrogen ions and probably with both. The ease with which iron compounds change valence and the tendency which they have to form compounds with mixed valence are well known.

Nitrogen forms five oxides: pentoxide, peroxide, trioxide, nitric and nitrous, and in combination with hydrogen, amine oxide and ammonium oxide. These oxides unite with water to form the series: nitric acid, nitrous acid, hyponitrous acid, hydroxyl amine, and ammonium hydroxide. Dilute nitric acid is one of the strongest acids known, while ammonium hydroxide and hydroxyl amine are bases. The intermediate compounds are weak acids.

A study of the properties of water solutions of nitric acid, of their action in electrolysis, and their reaction with metals, indicates that as the density increases the acid characteristics become weaker, and the basic characteristics become stronger, thus showing the amphoteric nature of nitric acid.

The reduction products which result when iron is dissolved in dilute acid are shown to be the consequence of the action of hydrogen ions in decreasing the valence of nitrogen. In consequence of this reduction electrons are removed from the iron by No+ and N+ ions. In concentrated acid, however, the hydrogen ion concentration is small, hence the reducing action upon the nitrogen does not occur. This results in electrons being removed from the iron by the No_2+ ions, which, on account of their oxidising character, increase the valence of the iron, thus forming ferric ions before any reaction takes place.

The observations are best accounted for by assuming that in concentrated acid the reaction is basic, *i.e.*, that the iron ions unite first with with hydroxyl ions.

The products of the electrolysis of nitric acid solutions and the formation of the passive condition when an iron anode is used in the electrolysis, are in strict agreement with these conclusions.

It is believed that the principles involved in this theory are of general application. Chromium forms a series of oxides similar to iron but with an additional acid forming oxide. When chromic acid is used as an electrolyte in the cell with an iron anode, the results are similar to those obtained with concentrated nitric acid. No matter how dilute the chromic acid solution may be, there is no indication that the acid reaction takes place. This might be expected since chromium compounds show a more strongly amphoteric character and chromic acid is much weaker and more oxydising than nitric acid.—*Physical Review*, October, 1921.

STELLITE.*

By ELWOOD HAYNES.

Realizing many years ago that an alloy that would take a cutting edge and at the same time resist the action of the atmosphere would fill a long-felt want, I made attempts even then to produce such a mixture or combination of metals. I found, however, that the problem was beset with many difficulties. Alloys containing copper were always subject to the tarnishing action of moist air and sulphuretted hydrogen; mixtures containing nickel and copper only possess the same disadvantages, though to a limited degree. Aluminium alloys with copper and nickel gave considerable hardness and a very high elastic limit, but they would tarnish in moist air, particularly in the presence of hydrogen sulphide.

In 1891 I made an alloy of nickel and tungsten, and, while this was not immune to acids, it resisted atmospheric influences remarkably well. This alloy was made by melting pure tungsten and pure nickel in a small crucible composed of a mixture of pure alumina and pure magnesia. The fusion was made in a small furnace of my own construction. The fuel used was natural gas, using air blast from a small foot-bellows.

Later, in 1898, I produced pure alloys of nickel and chromium by the reduction of their mixed oxides with pure aluminium. The alloy of nickel and chromium thus formed took a high polish, and retained its lustre in boiling nitric acid when the chromium constituted more than twelve to fifteen per cent of the alloy. This alloy could be filed rather readily, and could be worked cold into rods and sheets if sufficient care was exercised.

I next produced an alloy of cobalt with chromium in the same manner, but when the reaction took place a certain amount of free oxygen was evolved, and the metal was thrown from the crucible. This was due to the fact that the higher oxide of cobalt (Co_2O_3) was used,

* A paper presented at the American Electrochemical Society in Boston, April 9, 1920, reprinted from *Transactions of the American Electrochemical Society*, 1920, Vol. xxxvii.

while in the former experiment NiO was employed.

The reaction for the production of the nickel alloy was as follows:—

$$3NiO+Cr_2O_3+2Al_2=Ni_3Cr_2+2Al_2O_3.$$

The reaction in the case of cobalt was:—

$$2Co_3O_4+Cr_2O_3+3Al_2=Co_6Cr_2+3Al_2O_3.$$

It is obvious that by varying the proportions of the various oxides, alloys of varying compositions can be obtained.

It was only a step from this reaction to the production of the alloy by the simultaneous reduction of the oxides of their constituent metals by means of carbon.

Afterwards, they were produced on a commercial scale by melting pure nickel or pure cobalt with chromium. Since the cobalt-chromium alloys possessed great hardness and could be worked at a bright red heat, it seemed to be the more promising field for further investigation, and when, in the early part of 1900, large quantities of cobalt ore were discovered in Canada, and it became possible to procure the cobalt oxide at a comparatively reasonable price, I decided to place the alloy on a commercial basis.

The discovery of these alloys was first made public at a meeting of the American Chemical Society, in San Francisco, in 1910.

About this time I discovered that by adding tungsten or molybdenum to the cobalt-chromium alloy, its hardness could be very much increased, though the addition of either of these metals in any considerable quantity rendered the alloy unworkable either hot or cold. It could, however, be cast into almost any desired form, and when cast bars were ground to a cutting edge and placed in the tool-holder of a lathe, the alloy at once showed a considerable advantage over high-speed steel as a lathe tool.

The first remarkable test of this sort was made in the machine shop of the Haynes Automobile Company. A large boring mill had been purchased for boring cylinders. This mill was supplied with a boring head in which were inserted small radial cutters which bored out the interior of the cylinders directly from the rough castings. I was informed by our superintendent that he had found it impossible to work the mill to more than half its rated capacity on account of "burning" the steel tools. We had up to that time made only a few tests on the lathe of Stellite tools, but he was very anxious to try the alloy in the form of boring cutters. I accordingly produced a set of cutters of Stellite, which were inserted into the boring head. When I came to the factory the next day, about 11.30 in the forenoon, I asked the man at the mill what success he had achieved, and he replied that he "had a day's work out at twenty minutes of eleven in the forenoon." In fact, he was boring more than twice as many cylinders in a day with Stellite tools as could possibly be bored with steel ones. This test fully demonstrated the practical utility of Stellite tools.

In 1912, another paper was read on this alloy in New York, at one of the sessions of the International Congress of Applied Chemistry.

It was found quite difficult to make metal of uniform texture and quality in the form of castings, but most of the difficulties have been overcast tools of various kinds made of Stellite, which are of standard quality both as to strength and hardness.

The alloys are made almost entirely in electric furnaces of the Snyder type. The materials composing the alloy are placed in the furnace in the usual manner, and the current turned on. The alloy fuses rapidly, without much oxidation, under the intense heat of the electric arc. We find that of the metals composing the alloy, chromium is most readily oxidised, while cobalt seems to show more volatilisation, and tungsten is subject to the least change. It is true that the portion of furnace above the metal becomes filled with nearly pure carbon monoxide. This gas will oxidise chromium under certain circumstances at very high temperatures, though apparently no free carbon is produced in the furnace. This is probably because there is sufficient free oxygen or carbon dioxide to re-oxidise any carbon that may be temporarily produced.

At first much difficulty was experienced with the electric furnace linings, but after a certain amount of experimental work we were able to produce a magnesite lining which gives most excellent satisfaction in practice. When we first began the use of these furnaces, we considered ourselves fortunate if we could get eight or ten melts without either complete re-lining or heavy repairs. We now commonly obtain from two thousand to three thousand melts from a single lining, and some of them stand even higher than this.

The electric arc, on account of its extremely high temperature, causes a certain amount of volatilisation, or oxidation in the melting of many metals, but Stellite withstands the conditions remarkably well, particularly after the fusion is once made. In melting scrap, however, if certain precautions are observed, only a very slight loss is experienced in re-melting. Stellite can be melted in covered crucibles under suitable precautions with a loss of less than 2 per cent, and sometimes it does not even reach 1 per cent.

Not only have the Stellite alloys containing cobalt, chromium, and tungsten, or cobalt, chromium, and molybdenum shown great economic advantage as lathe tools, but the binary alloys (consisting of cobalt and chromium only) have likewise received a wide application in the form of dental instruments, surgical instruments, pocket knives, &c.

A modified Stellite alloy, known as Festel metal, consisting of cobalt, iron, and chromium, is also manufactured into table knives, which give excellent results in service.

All of the above alloys are practically immune to all atmospheric conditions, whether the air be moist or dry, or whether it contain minute quantities of sodium chloride or sulphuretted hydrogen. Knives made of this alloy can be used for cutting all sorts of fruit, including lemons, oranges, apples, &c., without becoming discoloured in the slightest degree. A new and interesting application of malleable Stellite is as a substitute for gold in the manufacture of pen points for fountain pens. The tips of these pens may, if desired, be made of extremely hard Stellite, which can be welded to the malleable alloy. This application is particularly gratifying because the metals replaced, gold and irrodos-

PROCEEDINGS OF SOCIETIES.

ROYAL SOCIETY.

November 17, 1921.

Prof. C. S. SHERRINGTON, President, in the Chair.

THE following papers were read :—

"The Design of Repeating Patterns." By Major P. A. MACMAHON, F.R.S., and W. P. D. MACMAHON.

The object of the paper is to provide a method for the study and classification of repeating patterns in space of two dimensions. It is founded upon the simplest geometrical forms which happen to be repeats. These are employed as bases and are subjected to specified transformations which depend upon certain contact systems between the sides which are in contact in the assemblage. The classification is based upon :—

(i) The base polygon;
(ii) The general contact system;
(iii) A subdivision of the contact system (ii).

Particular attention is paid to the design of symmetrcal repeats, and a calculus, with this object in view, is introduced. This involves a further sub-division of (iii) above into genera, each of which includes an infinite number of repeats. The symmetrical repeats based upon the equilateral triangle and upon the square involve 5 and 27 genera respectively.

Repeats themselves are of three varieties—the block, the "stencil," and the "archipelago"—the nomenclature of the last two being adopted at the suggestion of Mr. G. T. Bennett. There is a further broad division into normal and abnormal repeats.

A theory of "complementary repeats" is established and is believed to be of significance and importance. It is shown that a contour can be drawn around every normal repeat in an infinite number of ways, in such wise that the area within the contour, which does not belong to the repeat, is itself a repeat. The contour referred to, under specified conditions which can be determined, is itself the boundary of a repeat, which is therefore a combination of the original repeat and its complementary.

Repeats with circular boundaries (of the "stencil" variety) are brought forward and illustrated. By permission of Mr. Bennett, occasion is taken to announce his discovery of the fact that "every quadrilateral figure" is a repeat.

"A Problem in the Theory of Heat Conduction." By Prof. J. W. NICHOLSON, F.R.S.

The main problem is that of the conduction of heat outside a cylinder whose surface is maintained, from some specified instant, at a constant temperature for all subsequent time. A solution is obtained for the temperature at any point in the external medium, and for the rate of loss of heat from the cylinder at any instant. The principle of the method is the use of a generalised form of the Bessel-Fourier double integral. Subsequently a solution is obtained, in a similar way, for the general problem in which the temperature maintained on the cylindrical surface is not constant, but any arbitrary function of time.

"The Thermal Stresses in Spherical Shells Concentrically Heated." By Prof. C. H. LEES, D.Sc., F.R.S.

It is shown in this paper that the thermal stresses in the material of a furnace of approximate spherical form due to differences of temperature, and the stresses due to pressures on the inside and outside surfaces, may be expressed in simple form in terms of the volume of the spherical surface through any point or of its reciprocal. It is then shown that the expressions lend themselves readily to geographical representation, and lead to graphical methods of treating the whole problem. The elastic constants of the material have to be taken as constant, but it is shown how the variation of the dilatation with temperature may be taken into account.

The numerical values of the stresses in a furnace of fire-brick, with walls 20 cms. thick, whose surfaces are at 1100° C. and 100° C. respectively, are calculated, so far as they can be, with the constants available for fire-brick. The increase of stress due to sudden changes of temperature of the inside surface is discussed.

"Mathematical Foundations of Theoretical Statistics." By R. A. FISHER.

Methods of reduction of data implicitly involve interpretation of data to be handled as a random sample of some hypothetical infinite population, the parameters of which it is desired to estimate. In this process three types of problem arise: (*a*) to determine mathematical specification of population from which sample is regarded as drawn; (*b*) to estimate from sample the parameters of population; (*c*) to calculate distribution of statistics calculated from random samples.

The paper deals mainly with problems of estimation (*b*). Two criteria of adequacy of any particular method of estimation have hitherto been put forward: (1) the Criterion of Consistency merely requires that the method when applied to the whole population should yield the required parameter; (2) the Criterion of Efficiency compares the value of different statistics, suggested as estimates for a given parameter, by means of standard deviations of statistics from large samples.

The most efficient statistic is that which has least standard deviation; the efficiency of any other statistic is the ratio of number of observations required by most efficient statistic to that required by statistic under consideration in order to obtain a value of same accuracy.

It is shown that Criterion of Consistency is a special case of Criterion of Sufficiency, which requires that the sufficient statistic shall include the whole relevant information provided by sample. Efficiency of any other statistic may be looked upon as percentage of relevant information available and utilised by that statistic.

Proof is given that a certain class of statistic (those obtained by method of maximum likelihood) are always sufficient statistics, and therefore have least possible probable error. The standard deviation of these statistics being easily calculated, the efficiency of any other statistic, of known probable error, may be found.

"*The Diffraction of Plane Electromagnetic Waves of a Perfectly Reflecting Sphere.*" By F. P. WHITE.

This paper is an attempt to obtain from the well-known series solution for the problem of the diffraction of plane electromagnetic waves by a perfectly reflecting sphere approximations which are suitable for numerical evaluation when the radius of the sphere is large compared with the wave-length.

The method employed consists in transforming the series into a contour integral along a path of "steepest descents" and then approximating to the value of this integral. For points which are not nearly directly behind the sphere, the first approximation obtained agrees with that found by Dr. Bromwich (*Phil. Trans.*, A, 1920, ccxx., 196); second approximations are also obtained, which agree fairly well with the numerical results of Messrs. Proudman, Doodson, and Kennedy (*Phil. Trans.*, A, 1917, ccxvii., 279), for the case $\kappa a = 10$, a being the radius of the sphere and $2\pi/\kappa$ the wave-length.

The more difficult region behind the sphere is also investigated by a similar method, the integrals involved being here much more complicated, and the results are again compared with those of Proudman, Doodson, and Kennedy.

"*Whispering Gallery Phenomenon.*" By C. V. RAMAN and G. A. SUTHERLAND.

The paper deals with some observations made in the Whispering Gallery at St. Paul's Cathedral and also in the laboratory experiments, which show that, while Rayleigh's theory of the phenomenon is undoubtedly on the right lines, it does not offer a complete explanation of all that is observed. The optical analogue of the Whispering Gallery is described, and it is shown that the effect contemplated by Rayleigh, that is, a single belt of maximum intensity close to the wall, is obtained only in the limiting case when the radius of the reflecting circle is practically infinite in comparison with the wave-length. For more moderate values of the radius of curvature, we get a succession of belts of alternately great and small intensity. Similar effects are also observed in the acoustical case. The explanation of the resolts is discussed, and it is shown that the slight inevitable deviation from the condition of strictly circumferential wave-propagation postulated by Rayleigh must give rise to such effects.

SOCIETY OF GLASS TECHNOLOGY

A meeting of the Society of Glass Technology was held in the Fuel Department, the University, Leeds, on Wednesday, November 16, 1921, the President, Dr. MORRIS W. TRAVERS, F.R.S., in the Chair.

Following a demonstration by Mr. F. W. Knowles of an "Improved Gas Reversing Valve for Regenerative Furnaces", the meeting resolved itself into a discussion of problems connected with "The Melting of Glass".

A lively discussion took place upon various questions connected with the technique of glass-making. The President then announced that the next meeting would be held in London on December 14, 1921, and that by the courtesy of the Directors a visit had been raranged for the forenoon of that day to the works of Messrs United Glass Bottle Manufacturers, Ltd., at Charlton.

NOTES.

COMMERCIAL RESEARCH FELLOWSHIPS. — The Executive Council of the British Empire Exhibition announce five or more Commercial Research Fellowships for competition among Chambers of Commerce in the United Kingdom. The value of each Fellowship will be not less than £500, and will include a 1st-class return ticket to the Dominion, Crown Colony, &c., to which the Fellow will proceed. The subjects of research will be as follows: (1) The best means of promoting inter-imperial trade in a selected staple industry; (2) The methods whereby the British Empire Exhibition can further the interests of this trade; (3) The potential resources in raw materials, &c., in the Dominion or Crown Colony visited, and the best means for exploiting these in the mutual interest of the Dominion and this country; (4) The means whereby these undeveloped resources may be adequately represented at the British Empire Exhibition and brought to the attention of interested financial or industrial groups. Particulars of conditions can be obtained by application to the Secretary, British Exhibition (1923) Incorporated, 16, Hobart Place, London, S.W.1.

INSTITUTION OF RUBBER INDUSTRY.—Meetings will be held monthly at London and each of the following centres: Manchester, Birmingham, and Glasgow. Papers of practical interest to all sections of the rubber industry will be read at these meetings on dates to be announced later, as follows: "Ingredients of Ruhber Mixings," by Dr. Samuel S. Pickles, D.Sc.; "Widening the Field for Rubber Manufactures," by Fordyce Jones (Chairman, Reliance Rubber Co. Ltd.); "Vulcanisation—Past, Present, and Future," by Dr. Schidrowitz, Ph.D., F.C.S.; "Rubber Works' Worries," By Capt. F. J. S. Gray (Works Manager, S. Helens Cable & Rubber Co. Ltd.); "Cold Vulcanisation," by S. J. Peachey (The Peachey Process Co. Ltd.); "Rubber Pigments—Composition and Stability under Cure," by H. Dudley Ward; "Difficulties in Rubber Manufacture," by Dr. J. Torrey (Vice-President North-Western Rubber Co.); "Crude Rubber from the Consumers' Standpoint," by Dr. W. C. Geer (Vice-President, The B. F. Goodrich Co.); "Rubber Mixes and the Question of Accelerators," by J. L Rosenbaum (Hooley Hill Rubber and Chemical Co.); "Rubber Production"; "Troubles in Rubber Works"; "Rubber Proofing"; Special Rubber Machinery"; Electricity and its Uses in the Rubber Industry"; "Tyres—Solid and Pneumatic"; "Golf Ball Manufacture"; &c.

APPOINTMENT.—The Chancellor and Trustees of the University of Pittsburgh announce the appointment of Edward Ray Weidlein as Director of the Mellon Institute of Industrial Research.

CELLULOID.—In view of the increasing use of celluloid for industrial purposes and of its inflammable nature, many attempts have been made to produce a material that while possessing the valuable properties of celluloid shall be free from

fire risk. A new manufacture has been placed upon the market under the name of "Celastoid," which is claimed to have "all the good qualities of celluloid and none of the bad ones." Celastoid, or cellulose-acetate, can be obtained from the British Cellulose & Chemical Manufacturing Co., 8, Waterloo Place, London, S.W.

THE MAKING OF REFLECTING SURFACES.—Discussion at a *Joint Meeting of the Physical and* Optical Societies held on November 26, 1920, at the Imperial College of Science and Technology, South Kensington, S.W.7.—We have received from the Hon. Secretary (Papers) of the Optical Society, a copy of the Proceedings of this important discussion. The work opens with a survey of the Bibliography of Metallic Deposition on Glass, and of the more important papers on the Construction and Nature of Reflecting Surfaces, by R. Kanthack. The outcome of the Authors' interesting and exhaustive survey is that the fundamental discovery of a process for depositing silver upon a glass surface is due to Liebig, who, in 1853 published in the *Ann d. Pharm.* a method for depositing silver upon glass in the form of a brilliant mirror, by the action of aldehyde upon silver oxide in water. Since then, although very numerous papers have appeared upon the subject, very little real progress has been made, and the author concludes his survey by stating that "at the present time—85 years after Liebig's classical discovery—we have not evolved any method of chemical deposition on glass so scientific and practically perfect that it could be adopted officially." Then follows a list of the more important papers on the construction of reflecting surfaces commencing with a paper by S. Bernard, appearing in the *Jour. de l'Ecole Polytechnique*, Paris, in 1798, down to that of A. Silvermann and F. D. Neckermann that was published in the *Trans. Am. Chem. Soc.* in 1915. After this introductory survey, the following papers and discussions appear: Survey of the Bibliography of Metallic Deposition on Glass, by R. Kanthack; A Bibliography of the more important Papers on the Construction and Nature of Reflecting Surfaces, by R. Kanthack; Notes on the Formaldehyde Process of Silvering, by H. N. Irving; Some Workshop Notes on Silvering, by Sir James Weir French, D.Sc. (Messrs. Barr & Stroud, Ltd., Glasgow); The Silvering of Glass Reflectors by Chemical Deposition, by F. Ellerman and H. D. Babcock (Mount Wilson Observatory); The Silvering of a Large Reflector, by C. R Davidson (Royal Observatory, Greenwich); Note on the Silvering of Quartz and Glass Fibres, by R. S. Whipple, M.I.E.E. (The Cambridge and Paul Instrument Co. Ltd.); Some Notes on Mirrors used for Reflecting Heat Radiation, by Prof. Chas. Féry (*Ecole Municipale de Physique* et de Chimie, Paris); Deposition of Metals by Cathodic Spluttering in Vacuo, by F. Ellerman and H. D. Babcock (Mount Wilson Observatory); *Note on the Production of Mirrors by Cathodic* Bombardment, by F. Simeon, B.Sc., F.Inst.P. (Messrs. Adam Hilger, Ltd.); Platinum Reflecting Surfaces Prepared by the "Burning-in" Process, by *Julius Rheinberg*, F.R.M.S., F.R.P.S.; A Note on Mirrors for use in Optical Instruments under Industrial Conditions, by W. G. Collins (The Cambridge and Paul Instrument Co. Ltd.); A *Photometric Method of Measuring* the Reflecting Power of Mirrors, by John W. T. Walsh, M.A., M.Sc. (The National Physical Laboratory); General Discussion. The work, which is well *printed* and illustrated, is published by the Fleetway Press, Ltd., Dane Street, Holborn, W.C.1, price 5s. (postage 3d.).

TENDERS FOR TRADE SHIP.—The Directors of the British Trade Ship, of which Earl Grey is Chairman, announce that provisional tenders are being obtained by the builders of the ship for the various parts and fittings. Exhibitors who are in a position to supply some part or fitting as an exhibit actually in use on board, quite apart from their display in the Exhibition proper, are naturally anxious to have their products accepted for this purpose. At Wallsend-on-Tyne, where the ship will be built, and at the offices of the British Trade Ship, 12, Grosvenor Gardens, London, the examination of specifications is taking place with a view to determining the market value of each part and its exhibition value to the supplier. The examination is of considerable interest as revealing the place of different cities in the construction and equipment of the Trade Ship. Birmingham wants its bedsteads in the best cabins, Kidderminster its carpets, Bradford its textiles, not only on show, but in use; Sheffield its cutlery, and so on with hardware, machinery, leather, glass, and electrical goods. The trades mentioned make up two-thirds of the total exports of the country, and the realisation of this fact explains why the Directors of the Trade Ship are inundated with demands to provide exhibits which will be actual fittings of the ship The acid test which the builders will apply in all cases is that of quality, and, unless an exhibitor can satisfy them that his product is of the highest quality, it will not be included as part of the structure or of the fittings of the ship. When full arrangements have been completed, *the names of the chief firms responsible* for the various component parts of the Trade Ship will be published. The Trade Ship *British Industry* will go on its voyage as the representative of the manufactures of many cities.

BRITISH TRADE WITH FRANCE.—In order to assist in the stimulation of British trade with France, the British Chamber of Commerce in Paris is preparing a new and revised edition of its Franco-British Trade Index. The cost of compilation, classification, printing, and distribution of the Trade Index amongst French buyers will be met from the funds of the Chamber, the only *stipulation being that the* firms appearing therein, under the various classified headings of their manufactures or exports, shall have shown their interest in British Trade *in France by becoming members of the Chamber.* No subsidy is received by the Chamber from the Government, which entirely depends on the members' subscriptions to carry on its valuable work. *The membership roll at present includes nearly* 2000 British firms or subjects. Supplies of forms of application for membership and forms of insertions for the Trade Index, for distribution to *business friends, may be obtained on request to* the Secretary of the British Chamber of Commerce, 6, rue Halévy, Paris.—*Board of Trade Journal*, November 10, 1921.

NATIONAL CERTIFICATES IN CHEMISTRY TO STUDENTS IN TECHNICAL SCHOOLS AND COLLEGES IN ENGLAND AND WALES.—The Institute of Chemistry is undertaking the functions assigned to it in these Rules at the invitation of the Board of Education, and full particulars for the award of certificates can be obtained by application to H.M. Stationery Office, Imperial House, Kingsway, W.C.2, price 2d., or through any bookseller.

THE Council of the Institution of Electrical Engineers have elected as an Honorary Member Lord Southborough, P.C., G.C.M.G., &c., who was formerly Sir Francis Hopwood, and had a distinguished career at the Board of Trade and *other Government Departments.*

NEW COMPANIES.

The under-mentioned particulars of New Companies recently registered are taken from the Daily Register compiled by JORDAN & SONS, LIMITED, Company Registration Agents, Chancery Lane, W.C.2.

RIDING'S CASH DRUG STORES, LIMITED.—(177736)—Registered November 9th, 1921. 9, Wickham Lane, High Street, Plumstead To acquire and carry on the business of Chemist, Druggist and Drug Stores. Nominal Capital: £1,200 in 1,200 Ordinary Shares of £1 each. Directors: W. E. Hallock, 9, Wickham Lane, Plumstead. S.E.18; (Mrs.) Emily Hallock, 9, Wickham Lane, Plumstead, S.E.18.

ALFRED BOND, LIMITED.—(177711)—Registered November 8th 1921. To acquire and carry on the business of Chemists and Druggists. Nominal Capital: £16,000 in 16,000 Shares of £1 each Directors: A. Bond, 45, Bank Street, Newquay; C. E. Whetford Rosemellny, St. Columb; M. Gatley, Fore Street, St. Columb Qualification of Directors: 250 Shares. Remuneration of Directors £150 to be divided.

POMMEROLS CURE, LIMITED.—(177899)—Registered November 18th, 1921. 72-74, Victoria Street, Westminster, S.W.1. To carry on the business of Chemists and Druggists. Nominal Capital: £2,000 in 2,000 Ordinary Shares of £1 each. Directors: J. G. L. Pommerol, 27, Richmond Road, Bayswater, W.2.; E. H. Hove White Cottage, Wargrave, Berks.; F. Hill, Vaughan Lodge, Long Ditton, Surrey; J. Molendri, 53, James Street, Cardiff. Qualification of Directors: 1 Share. Remuneration of Directors: To be voted by Company in General Meeting.

New Patents.

THIS List is specially compiled for the *Chemical News* by Messrs Rayner & Co., Registered Patent Agents, of 5, Chancery Lane, London, W.C.2., from whom all information relating to Patents. Trade Marks and Designs can be obtained gratuitously.

Latest Patent Applications.

29198—Briggs, A.—Treatment of iron liquors containing zinc an sulphate of soda. November 3

29137—British Cellulose & Chemical Manufacturing Co. Limited.—Treatment of cellulose derivatives. November 2

29289—British Dyestuffs Corporation, Ltd.—Manufacture of phenyl glycine or compounds thereof. November 3

29902—British Dyestuffs Corporation, Ltd.—Mono-nitro and mono-amino derivatives of P-halogenated dialkylanilines. November 9

30119—Chemicals & By-Products, Ltd.—Indicator for determining weak acids or bases in the presence of strong acids and bases, etc. November 11

30005—Air Liquide Soc Anon pour l'Etude et l'Exploitation des Procedes G.—Apparatus for synthesis of ammonia. November 10

30089—Whyte, D.—Process for conversion of sulphite of lead water paste into oil paste. November 11

Specification published this Week.

170613—South Metropolitan Gas Co., and Parrish P.—Manufacture of ammonium sulphate

Abstract Published this Week

Synthetic Resins.—Patent No. 16934.—A method of producing Synthetic Resins has been Patented by Mr. H. V. Potter and W. F. Fleet, 98, Bradford Street, Birmingham, and Damard Lacquer Co. Ltd., 82, Victoria Street, Westminster, Phenol or its homologues when condensed with acetaldehyde or its polymers produces a resin which is soluble and does not harden on heating. Formaldehyde or its polymers may be added at any stage of the process to render the product less soluble or insoluble or to make it harden. Acids, bases and salts may be used as accelerators, the following being mentioned as suitable, namely sulphuric acid, ammonia, caustic-alkali, oxalic acid and phenyl hydrazine hydro-chloric.

Nickel; Sodium Salts.—Patent No. 169247.—A process for obtaining Sodium Salts has been Patented by Mr. E. E. Naef, 16, Loughborough Road, West Bridgford, Nottingham. Finely divided nickel sulphide is heated with solid caustic soda, or with a mixture of caustic soda and sodium carbonate, common salt, sodium sulphate, sodium sulphide, or lime, and with or without the addition of powdered coal. The operation may be carried out in an atmosphere of hydrogen or gases containing hydrogen. Sulphides, hydrosulphides, and thiosulphates of sodium are formed and metallic nickel is precipitated, which, after slight reduction in hydrogen is applicable as a catalyst in processes for the hydrogeneration of oils. The molten salts may be poured off, or the whole mass may be treated with water to dissolve the salts. The nickel may be refined electrolytically or by a carbonyl process, or converted into sulphate.

Messrs. Rayner & Co., will obtain printed copies of the published specifications and will forward on post free for the official price of 1/- each.

MEETINGS FOR THE WEEK

Monday, December 5.

Royal Society of Arts, 8.—(Cantor Lecture.) "Processes of Engraving and Etching" by Arthur M. Hind.

Institute of Electrical Engineers, 7. Discussion on "Some Recent Developments in the Design of A.C. Instruments".

Tuesday, December 6.

Royal Society of Arts, 4.30 "British Columbia" by Frederick C. Wade.

Wednesday, December 7.

Royal Society of Arts, 8. "Literature and International Relations" by Emil Cammaerts.

Society of Public Analysts, 8. "Estimation of small quantities of Antimony in Copper and Brass" by B. S. Evans. "The Inks of Ancient and Modern Egypt" by A. Lucas. "Analysis and Use of Red Squill in Rat Poisons" by C. L. Claremont.

Institution of Electrical Engineers, 6. An Investigation of Transmitting Aerial Resistances" by T. L. Eckersley.

Thursday, December 8.

Royal Society. "A Study of the Glow of Phosphorus. Periodic Luminosity and Action of Inhibiting Substances" by Lord Rayleigh. "The Aurora Line in the Spectrum of the Night Sky" by Lord Rayleigh. "The Energy in Air, Steam, and Carbon Dioxide from 100° C. to 2,000° C." by W. D. Womersley. "Atmospheric Pressure and Refractive Indices with a corresponding Table of Indices of Optical Glass" by Lt. Col. J. W. Gifford. "A new Form of Interferometer" by H. P. Waran. "Viscosities of the Hydrogen Halides" by H. Harle.

Chemical Society, 8. "The Genesis of Ores" by Professor J. W Gregory.

NOTICES.

EDITORIAL.—All Literary communications and Books, Chemical Apparatus, &c., for review or notice to be addressed to the EDITOR.

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ROYAL SOCIETY—GOVERNMENT GRANT FOR SCIENTIFIC INVESTIGATIONS.

APPLICATIONS for the year 1922 must be received at the Offices of the Royal Society not later than January 1st next, and must be made on printed forms to be obtained from the Clerk to the Government Grant Committee, Royal Society, Burlington House, London, W.1.

THE CHEMICAL NEWS.
VOL. CXXIII., No. 3217.

THE PRESENT POSITION OF THE THEORY OF DESCENT, IN RELATION TO THE EARLY HISTORY OF PLANTS.*

By H. D. SCOTT, LL.D., F.R.S.

(Concluded from page 293.)

THERE is one more point in connection with the Rhynie plants which may be mentioned, as it is of purely morphological interest, and may be more in place here than at a later stage of the discussion.

In *Hornea*, as Kidston and Lang have shown, the terminal "sporangia evidently arose by the transformation of the tips of certain branches of the plant."

They are, in fact, very little modified as compared with vegetative parts of the stem. The epidermis and subjacent layers of the sporangial wall differ but slightly from the corresponding tissues of the branch, while the columella is continuous with the phloëm, and resembles it in structure. The sporangium has no special stalk, and in some cases is forked, like the stem, having evidently been formed when the branch was in the act of dichotomy.

In *Rhynia* the sporangia are better differentiated, but here also cases occur where the spore-bearing region differs little in structure from the branch which it terminates. In both genera the spore-containing organ is thus nothing but the more or less altered end of a branch, quite comparable to the stichidium, which is differentiated in some Red Seaweeds as the receptacle of the tetraspores, while in other Algæ of this group the tetraspores are produced in unaltered portions of the thallus. In *Hornea* the fertile branch-ending is less differentiated than in *Rhynia*, and we must be prepared to meet with related forms in which the spore-hearing region was not differentiated at all, except for the presence of the spores.

Goebel taught that the sporangium was an organ *sui generis*, a special reproductive structure, which had never arisen from any vegetative part of the plant ("Vergleichende Entwickelungsgeschichte der Pflanzenorgane." Schenk's "Handbuch der Botanik," Bd. III., Part I., 1884, p. 130). His view has been generally accepted, but, in the light of the conditions in Rhyniaceæ, appears to be no longer tenable. While the spores may still be described as organs *sui generis*, for there have always been reproductive cells since plants became multi-cellular, the sporangium proves to be really a portion of the vegetative stem or thallus, which has gradually become specialised as a receptacle for the spores. The sporangium thus turns out to be strictly homologous with a definite part of the vegetative body of the plant. In these remarks I am glad to find myself entirely in accord with the views of Kidston and Lang, as stated in their fourth memoir on the Rhynie plants.

The recent work on the Early Devonian Flora has wide bearings. It has long been noticed that among the fossils of that period no typical Fern-fronds are found. Those remains which are most suggestive of Fern-like habit consist merely of a naked-branched rachis. It used to be assumed that the absence of a lamina might be explained by bad preservation. But, as Prof. Halle points out, the chief reason for condemning the preservation as bad was the fact that a lamina was absent!

The evidence really seems to indicate that the so-called fronds of that age did not possess a leaf-blade. As Prof. Halle says: "In the Lower Devonian, finally, we find frond-like structures bearing sporangia, but no fronds with developed laminæ. One can hardly escape the conclusion that the 'modified' fertile fronds may represent the primitive state in this case, and that the flattened pinnules are a later development, as suggested by Prof. Lignier" (T. G. Halle, "Lower Devonian Plants, from Röragen, in Norway," Stockholm, 1916, p. 38). These naked fronds may, in fact, be regarded as the little-differentiated branches of a thallus. It is often impossible to say whether we have to do with the ramification of a stem or with a frond, Halle even suggests that one of his species of *Psilophyton*, *P. Goldschmidtii*, may furnish us with an intermediate stage between the two, as required by Lignier's hypothesis. Plants of the *Rhynia* type may represent a still earlier phase, in which there was no differentiation whatever, but merely a branched thallus. It is a curious point that "the circinate vernation of the Fern-fronds is paralleled in the branches of *Psilophyton princeps*.

The evidence, as at present understood, seems to suggest that, in the earlier Devonian flora, Ferns, properly so called, may not yet have been in existence. The predecessors of the Ferns (Lignier's "Primofilicinées," *not* Arber's "Primofilices") were there no doubt, but not, so far as we know, the Ferns themselves. Yet it seems that highly organised stems of a Gymnospermous type were already present at about the same period. Thus the evidence from the older Devonian Flora, so far as it goes, materially supports the opinion that the Seed Plants cannot have arisen from Ferns, for the line of the Spermophyta seems to have been already distinct at a time when true Ferns had not yet appeared.

The idea that the Gymnosperms were derived, through the Pteridosperms, from the Ferns, which I once advocated, must, I think, be given up, on grounds which were stated two years ago at the Bournemouth meeting of the Association. It is safer to regard the Pteridosperms, and therefore the Seed Plants generally, as a distinct stock, probably as ancient as any of the recognised phyla of Vascular Cryptogams, and derived from some unknown and older source. At the same time the striking parallelism between the Pteridosperms and the true Ferns must be recognised. These views are essentially in agreement with those previously expressed by my friend Dr. Kidston.

I may be permitted to quote in this connection an interesting remark made by Prof. Paul Bertrand in a letter received last year. He was speaking of a strange group of plants of Lower Carboniferous or possibly Upper Devonian age, the Cladoxyleæ. These plants have a complex

*Address delivered before Section K, British Association (Edinburgh Meeting).

polystelic structure in both stem and petiole, but seem to be quite distinct from the later and better-known polystelic family, Medulloseæ. Prof. Bertrand, the chief living authority on the Cladoxyleæ, speaks of them as very primitive types, in which the distinction between stem and petiole was still but little marked. Yet he considers them as most probably Phanerogams. These views, if confirmed, imply that the Phanerogams or Seed Plants started as a distinct phylum, quite low down, at a phase when the differentiation between stem and leaf was still incomplete.

Without laying too much stress on an expression of opinion such as Prof. Bertrand's, I believe the present evidence is in harmony with the view he suggests. The Spermophytes, as it seems, have been an independent class of plants from very early times; they are not to be derived from the Vascular Cryptogams, as we have hitherto conceived them, but are of the same standing with them, having sprung from some long-extinct stock, comparable, perhaps, to Kidston's and Lang's Psilophytales, though not necessarily on the same line.

The significance of the Pteridosperms has perhaps been somewhat misunderstood. It now seems that they do not, as some of us once imagined, indicate the descent of the Seed Plants from Ferns, but rather show that the Seed Plants passed through a Fern-like phase; they ran a parallel course with the true cryptogamic Ferns, and, like them, sprang from some quite early race of land plants, such as Rhynic has revealed to us. But the phylum was never any more Fern-like than the Pteridosperms themselves. This, at least, is the view which now suggests itself, but our knowledge is still very meagre. We especially want to know more about the Devonian Spermophyta, for at present we have scarcely any evidence even of the existence of seeds in any Devonian Flora. Such data as we possess are all anatomical, and a disciple of Williamson must be on his guard against the risk of repeating the old mistake of the Brongniartian school.

Having ventured so far into speculative regions, it may be well to return for a moment to the facts, and ask to what extent our knowledge of the Fern-like Seed Plants has advanced since the original discoveries of 1903-1906. I fear that there is not very much to record. We now have one or two additional species of *Neuropteris* bearing seeds, and also the probable seed of *Heterangium*. Further, we have various indications of the characters of the pollen-bearing organs in some Pteridosperm genera, though the documents, being mostly in the form of impressions, are deficient in detail. Such new information as has come to hand confirms in a satisfactory manner our former conclusions, but does little to extend them.

On the anatomical side there has been more liveliness. We now know quite a number of Palæozoic plants, of varied structure, which have something in common with the better-established Pteridosperm families, Lyginopterideæ and Medulloseæ, while they certainly have nothing to do with Lycopods, Horsetails, or Sphenophylls. We therefore call them Cycadofilices or Pteridosperms. I prefer to use one name for them all and incline to the latter, for, while the plants are more or less Fern-like in structure, many of them show no special resemblance to Cycads.

At present we know of no fewer than eight families, based mainly on anatomical characters, which we provisionally include under Pteridosperms :—

1. The familiar Lyginopterideæ (Lower and Upper Carboniferous).
2. The *Rhetinangium* family, founded on Dr. Gordon's new genus (Lower Carboniferous).
3. The Megaloxyleæ, discovered by Prof. Seward (Upper Carboniferous).
4. The Calamopityeæ, recently enriched by Dr. Kidston with a new genus, besides new species (Lower Carboniferous).
5. The *Stenomyelon* family, another of Dr. Kidston's discoveries, described by him in conjunction with Gwynne-Vaughan (Lower Carboniferous).
6. The *Protopitys* type, a singularly isolated one, elucidated by Solms-Laubach (Lower Carboniferous). The above are all monostelic. Next come the two essentially polystelic groups :
7. Cladoxyleæ, already mentioned, a somewhat mysterious race, of Lower Carboniferous or possibly even Upper Devonian age.
8. The well-known Medulloseæ (Upper Carboniferous).

It is noticeable that five of these families are Lower Carboniferous (or possibly, in certain instances, older); one (Lyginopterideæ) includes both Lower and Upper Carboniferous members, while two (Megaloxyleæ and Medulloseæ) are at present known only from the Upper Carboniferous).

Of the eight families in question there are only two (Lyginopterideæ and Medulloseæ), in which we have any evidence as to the fructification The other six are known only by their vegetative and mostly by their anatomical features. Of these, the Protopityeæ and the Cladoxyleæ are the most isolated, differing, for example, in the structure of their tracheides from the other families. There seems to be no reasonable doubt that the families represented by *Lyginopteris, Rhetinangium, Megaloxylon, Calamopitys, Stenomyelon,* and *Medullosa* are related, and belong to one and the same main phylum. Considering that members of two widely separated families in this series are known to have borne highly organised seeds, there is a strong presumption that the whole set were reproduced by seeds of some sort. In the case of the two families Protopityeæ and Cladoxyleæ the marks of affinity are less obvious, but even here there is more in common with the type-families Lyginopterideæ and Medulloseæ than with any other group.

I think then that we are justified, in the present very imperfect state of our knowledge, in provisionally keeping all these families together, as probably, in some wide sense, Pteridosperms. On this view, they formed a distinct, extensive, and varied class of plants, already very well developed in Lower Carboniferous times, and no doubt going back to the Upper Devonian, though here the available evidence is scanty.

The question may be asked : Did all the Seed-plants pass through the Pteridosperm phase, or were there other parallel lines of descent? Some

recent work, no doubt, tends to link up the Cordaitales with the Pteridosperms. *Mesoxylon*, for example, is merely a *Cordaites* with centripetal wood in the stem, a character which strongly suggests an affinity with the *Lyginopteris* or *Calamopitys* type. In fact, some members of the Calamopityeæ (Zalessky's *Eristophyton*) show a certain approach to Cordaitales.

A more striking point is that no marked distinction has been found between the seeds of Pteridosperms and those of Cordaitales. The general community of seed-structure is strong evidence of close affinity and of a common stock.

There seems to be no proof that the family Cordaiteæ existed as such in Devonian times; we do not know much about them even in the Lower Carboniferous; the family is typically Upper Carboniferous and Permian. On the other hand, the *Pitys* family, which we include in the wider group Cordaitales, is as old as any known Pteridosperm; Zalessky's genus *Callixylon*, an evident ally of *Pitys*, is of Upper Devonian age. The affinities of the still more ancient *Palæopitys Milleri* have not yet been determined.

The position of the Pityeæ hangs in the balance, at least until Dr. Gordon's new results are fully placed before us. From his discovery of the peculiar foliage and leaf-traces as well as from the stem-structure it appears that the Pityeæ form a very distinct group, farther from the other Cordaitales than we at once supposed, and not much like any of the Pteridosperms either. At any rate, we may suppose that the Pityeæ branched off from the common stock low down while the Poroxyleæ and Cordaiteæ may have been of later origin. For the present, however, one may be content to regard the early Spermophytes as constituting a single main phylum. Since these words were written, however, Dr. Margaret Benson has maintained a contrary view, arguing that the Cordaitales, Ginkgoales, and Conifers represent a wholly distinct stock, more allied to the Sphenopsida than to the Fern-like races ("The Grouping of Vascular Plants," *New Phytologist*, June 30, 1921). The independence of this line has also been maintained by Prof. Chamberlain ("The Living Cycads and the Phylogeny of Seed Plants," *American Journal of Botany*, 1920, vii.) and discussed by Prof. Sahni ("The Structure and Affinities of *Acmopyle Pancheri*," *Phil. Trans. R. Soc.*, Ser. B., 1920, ccx.).

On our hypothesis, the Upper Palæozoic phyla, with which we have to reckon, are the Pteridosperms (representing the early phase of the Seed-plants), the Ferns, the Sphenophylls, the Equisetales, and the Lycopods. These five lines were probably all well differentiated in the Upper Devonian Flora; the only doubt concerns the Equisetales, which seem not to be known with certainty before the Lower Carboniferous, but they were so well developed then that they must have existed earlier.

When we get back to the Middle and Lower Devonian the case is completely altered. Not one of the five phyla is here clearly represented, unless it be the Spermophyta; for these we have the evidence of apparently Gymnosperm-like stems. Thus the field is left absolutely open to speculation. We may imagine, either that the various phyla converged in some early vascular stock (illustrated by the Psilophytales), or that they ran back in parallel lines to independent origins among the transmigrant Algæ and, perhaps further still, to separate races of purely marine plants. Both views are represented in the publications of recent authors.

Dr. Arber, in his "Devonian Floras," maintained the early existence of three distinct lines of descent: the Sphenopsida, Pteropsida, and Lycopsida. In agreement with the present writer, he included the Equisetales in the Sphenopsida. Each of the three lines is described as descended from Thallophytic Algæ of a distinct type. Thus Arber's view was decidedly polyphyletic. It must, however, be borne in mind that the supposed ancestral "Algæ" were plants in which he expected to find "some form of primitive vascular system, at least as far advanced as in *Psilophyton* (*l.c.* p. 74).

Arber derived the Spenopsida from Algæ bearing whorled branches of limited growth, converted into leaves, which were originally and always microphyllous. The Pteropsida, with which he associated his Palæophyllales (*Psygmophyllum*, with foliage like the Maiden-hair tree), were descended from Algæ in which the branches were large, numerous, scattered, and not whorled, eventually metamorphosed to megaphyllous leaves. The Lycopsida, on the other hand, were derived from Algæ in which the usually dichotomous axis bore emergences, metamorphosed to microphyllous leaves.

Thus, as regards the origin of the leaf, Arber was in general agreement with Lignier, while he differed from the French author in the important point that he did not derive the Sphenopsida from the Fern-stock, but kept them as an independent line.

A remarkable feature in Arber's hypothesis is his treatment of the Psilotales. He made this problematic family "a quite independent race, also of Algal origin, which appeared on the scene long after the other races . . . possibly in Mesozoic times or even later" (p. 87). Thus he rejected both the connection with Psilophytales, suggested by Kidston and Lang, and the affinity with Sphenopsida, once maintained by the present writer.

We thus see that, on Arber's view, there were altogether four distinct lines of descent, running back independently to "Thallophytic Algæ."

Dr. Church, from a different point of view, arrives at somewhat similar conclusions, but he goes further. He says: "Speaking generally, it appears safer to regard a 'race' or 'phylum' as the expression of a group of organisms which derived their special attributes from the equipment of a preceding epoch, if not in one still further back. Thus all the main lines of what is now Land Flora must have been differentiated in the Benthic Epoch of the sea (*i.e.*, as Algal lines), as all Algal lines were differentiated in the Plankton phase The possibility is not invalidated that existing groups of Land Flora may trace back their special line of progression to the flagellated life of the sea, wholly independently of one another (Pteridophyta)". ("Thalassiophyta," p. 41).

Taking the Lycopods and Ferns as an example, and arguing from their different types of flagellated spermatozoids, Dr. Church states: "It appears impossible to avoid the conclusion that

the Lycopod phyla only merge with those of the Filicineæ in a distant Plankton phase, even beyond an independent origin as benthic sea-weeds" (*l.c.*, p. 82). Thus the idea of independent parallel lines of descent is carried to its extreme limit. "Each phylum goes back the whole way, without any connection with anything else." Of course, this thorough-going polyphyletic conception is involved in the doctrine already mentioned —that morphological differentiation was attained in the sea before the transmigration.

I have cited Dr. Arber and Dr. Church as independent representatives, approaching the question from quite different sides, of the polyphyletic or parallel-phyla hypothesis. The opposite view, of convergent monophyletic races, is also well supported. Some reference has already been made to Prof. Halle's position. After speaking of the possible relation of the *Psilophyton* type to Lycopods on the one hand, and Ferns on the other, he adds: "From this point of view the whole pteridophytic stock would be monophyletic, the Lycopsida and the Pteropsida being derived from a common form already vascular. It would not thus be necessary to assume a parallel evolution of a similar vascular system along two different lines." (Halle, *l.c.*, p. 39).

He does not refer to the Articulatæ, of which, it is true, there are only the most doubtful indications in the Lower Devonian rocks. Halle, too, accepts Lignier's view of the two-fold origin of the leaf, from emergences in the Lycopsida, from thallus-branches in the Pteropsida.

Kidston and Lang, in the light of their Rhynie discoveries, regard Halle's survey as "a fair statement of the present bearing of the imperfectly known facts." They lay great stress on the synthetic nature of their genus *Asteroxylon*, which they say "appears to agree with *Psilophyton* in possessing in a generalised and archaic form characters that are definitely specialised in the Psilotales, Lycopodiales, and Filicales." They add: "The Geological age and succession of the Early Devonian plants, are, on the whole, consistent with the origin of the various groups of Vascular Cryptogams from a common source ("Old Red Sandstone Plants, showing structure, from the Rhynie Chert Bed," Part III., p. 673. In Part IV. this conclusion is further emphasised, and it is suggested that the Rhyniaceæ are really too simple morphologically to suit the views of either Lignier or Church). We have already referred to the Bryophytic features, which have been recognised in the Rhyniaceæ. Kidston and Lang make use of these to extend their tentative conclusions to the Bryophyta. In concluding their third memoir they say: "In *Rhynia* and *Hornea* we have revealed to us a much simpler type of Vascular Cryptogam than any with which we were previously acquainted. This type suggests the convergence of Pteridophyta and Bryophyta backwards to an Algal stock. The knowledge of *Asteroxylon* confirms and enriches our conception of a more complex but archaic type of the Vascular Cryptogams, which supports the idea of the divergence of the great classes of Pteridophyta from a common type, and links this on to the simpler Rhyniaceæ" (*l.c.*, p. 675). The monophyletic view, though stated with appropriate caution, could not be more clearly expressed. It is fully maintained in these authors' latter statements.

It is evidently impossible to decide between the two theories in the present state of our knowledge; we are now only beginning to acquire some conception of the vegetation of Early Devonian times. The discovery, however, of the existence at that period of an unexpectedly simple race of vascular plants to some extent favours a monophyletic interpretation, even though we accept with some reserve the wonderful synthesis of characters which *Asteroxylon* appears to exhibit. To some minds, too, the important points in which all existing Pteridophyta, however diverse, agree will still suggest a common origin not too remote. Among such common characters may be mentioned the alternation of generations with the sporophyte predominant; the development both of the spores and the sexual organs; and the histology, especially of the vascular system and the stomata. The community of reproductive phenomena is explained by Dr. Church on the principle that reproductive phases are inevitable, and are therefore the same in all phyla. A like explanation may to a certain extent be applicable to somatic features, some of which may be the necessary consequences of the sub-aerial transmigration. Thus a polyphyletic hypothesis may no doubt be justified, but it urgently needs to be supported by further evidence of the actual existence of separate stocks among the earliest available records of a Land Flora.

The study of Fossil Botany has led to results of the utmost importance, in widening our view of the Vegetable Kingdom and helping to complete the natural system, to use Solms-Laubach's old phrase once more. One need only mention the Mesozoic Cycadophytes, the Cordaitales, the Pteridosperms, the Palæozoic Lycopods and Equisetales, the Sphenophylls, and now, most striking of all, the Psilophytales, to recall how much has been gained. We have indeed a wealth of accumulated facts, but from the point of view of the Theory of Descent they raise more questions than they solve. In this address I have briefly touched on some of the most general and speculative problems in the hope of giving an opening for discussion. It might have been more profitable to deal in detail with definite facts of observation, but recent discoveries have brought us face to face with the great questions of descent among plants. However imperfect our data may be, both as regards the method and the course of evolution, the problems suggested, nevertheless, make urgent claims on our attention.

HELIUM-BEARING NATURAL GAS.

By G. SHERBURNE ROGERS.

Scope of the Investigation.

THE gas helium, which was discovered on the earth by Sir William Ramsay in 1895 and which was at first regarded as one of the rare elements, was found in 1905 by H. P. Cady and D. F. McFarland to occur in small proportion in natural gas from many localities in Kansas. The announcement of this discovery excited interest in scientific circles, but as no practical use for helium was known it had no industrial value, and efforts were not made to extract it except in very small quantities for experimental use. During the first year of the World War, how-

ever, a British scientist conceived the idea of using helium instead of hydrogen for inflating balloons, and in 1915 a vigorous but unsuccessful search for the gas in England was begun under the direction Sir William Ramsay. This search was later extended to Canada, but without attaining satisfactory results. On the entrance of the United States into the war the project was revived, and this Government undertook an energetic campaign for the production of helium in large quantities.

The value of helium for inflating balloons was brought to the attention of the Army and Navy by the Bureau of Mines, and that Bureau was commissioned to investigate the practicability of extracting the gas in large quantities and at a reasonable cost. When the technologic feasibility of the project was assured, the Geological Survey was called upon to investigate the helium resources of the country, in order to locate the richest supplies of the gas and to form estimates of the quantity available. This paper is based on the results of that investigation and describes the distribution and geologic relations of helium-bearing natural gas, making only brief mention of the technologic problems involved in the extraction and purification of the helium.

As the Survey's investigation was made strictly for military purposes it was necessarily directed toward locating an adequate supply of helium-bearing gas as speedily as possible, and practically no attention was given to the broader scientific problems involved in the origin or ultimate source of the helium. Considerable research will evidently be necessary before this problem can be successfully attacked, and in view of the probable development of commercial aircraft during the coming decade, and the probability that the cost of extracting helium from natural gas will be reduced sufficiently to permit its use in commercial balloons, it has been deemed desirable to present immediately a brief description of the chief sources of helium in the United States. At the same time the writer has endeavoured to describe the broader geologic relations of the helium-bearing gas, to discuss various theories of its origin, and to review the reported occurrences of helium in minerals and in other gases, in the hope that such a presentation of the problem will be of value to others who may later attempt to solve it.

Value of Helium for Inflating Balloons.

The value of helium for inflating balloons, especially airships of the Zeppelin type, lies in its lightness and its incombustibility. Hydrogen, the gas commonly used for inflating balloons, is the lightest substance known, but mixed with air it is explosively combustible. For this reason a balloon filled with hydrogen is very liable to be set afire, either by atmospheric electricity, by sparks from its power plant, or by any one of numerous accidents which may occur even when it is in its hangar. The fire hazard is, of course, greatly increased in balloons used for military purposes, a single incendiary bullet being usually sufficient to destroy a great airship; and this weakness, inherent in all hydrogen-filled balloons, was not only a potent factor in the practical failure of the German Zeppelin programme, but has always been a serious drawback to the development of lighter-than-air craft. On the other hand, Assistant Secretary of the Navy Roosevelt is authority for the statement: "With the fire risk eliminated the rigid airship or Zeppelin will hence be one of he most powerful weapons known (*Official Bulletin U.S.*, March 18, 1919, p. 9).

Helium weighs 0·01121b. per cubic foot, and is thus twice as heavy as hydrogen, which weighs only 0·00561b. per cubic foot. In comparison with air, however, both gases are so light that this difference is of small practical importance, and the lifting power or buoyancy of helium is 93 per cent of that of hydrogen. The slightly greater weight of the helium is, moreover, far more than offset by its chemical inertness, for as helium does not combine with oxygen it cannot explode or burn. Furthermore, its rate of diffusion is only about half that of hydrogen, and consequently it passes through the balloon fabric and wastes much more slowly. The chief advantage of helium, however, is obviously its incombustibility, for fire is one of the greatest of the hazards to which ordinary balloons are subject. Moreover, the use of a non-inflammable gas permits modifications in the design of airships which make for greater speed and cruising radius, as well as for greater military efficiency. In view of these advantages, it is apparent that the use of helium for inflating airships, both military and commercial, will be limited solely by the supply of helium available and the expense at which it can be produced.

The painstaking and little-noticed research which led to Prof. Cady's discovery of helium in natural gas, and the conception of another scientist ten years later that balloons might be made far safer and more efficient if inflated with helium, furnish an inspiring example of the practical value which purely scientific achievements may assume in course of time.—*Professional Paper* 121, U.S. Geological Survey, Department of the Interior.

VENTILATION AND HUMAN EFFICIENCY.*

The Author (Dr. Leonard Hill), in introducing his paper, said that Capt. S. R. Douglas and he had recently carried out some researches by making a spray of microbes into a room, where the windows were closed or opened; they had exposed culture plates after spraying a measured quantity of a dilute culture of an easily identified microbe which was carried up to the ceiling by means of a fan. Culture plates were exposed for two minutes in the different parts of the room after two minutes, and then after five minutes, and ten minutes, and so on, up to twenty minutes. The spray of microbes settled down by gravity, some of them on the plates. Then the plates were put into a warm chamber, and any microbe which had settled on the plate grew and multiplied into a colony. They had been able to distinguish the right microbe by the character of the colony. All those crowds of colonies were produced two minutes after making the spray in the room with windows open or closed.

A slide projected on the screen showed the difference in 20 minutes. Only one microbe had

* Discussion before the Institution of Mining and Metallurgy, October 27, 1921.

fallen on the plate with the window open, and the number that fell with the window shut could be seen. It was necessary to remember that all the people in a crowd who were speaking and sneezing and coughing were spraying out microbes from their throats and noses in a fine spray, just like the spray which had been used in the experiment. People who were carrying influenza and consumption and common colds, and so on, were throwing out those microbes and infecting other people in the room. If it were possible to get rid of those microbes a great deal would have been done towards improving health. They could not be got rid of altogether, but it was possible to lessen the massiveness of infection.

Mr. Greenwood gave him the clergy as the standard of health. The figures had been taken from the Registrar-General's reports. A clergyman lived a regular life and did not indulge to excess like some weaker brethren might, but lived a life which was fairly easy and not very anxious. In some cases clergymen worked very hard, but on the whole they lived an easy life. They walked about and played games, and so on, and were a good deal in the open air. It would be seen that their death-rate at all ages was very low. It was a very good standard to take. The death rate of agricultural labourers with a low wage was a little higher. In spite of their low wage, by living an outdoor life and getting the garden produce, the green vegetables, and so on, which were very valuable to their health, they had the death-rate shown on the screen. Then they came to the cotton manufacturers who were higher, and shoe makers who were still higher, and the printers. Both from phthisis and from all causes the death-rate went up considerably with regard to the indoor factory occupations.

He had gone into the figures of the expectation of life of females with Mr. Greenwood. He had taken females because they were not so much damaged by other causes such as their occupation or trade. Females in Westmorland had at birth an expectation of life of 61 years, while in Middlesbrough at birth their expectation of life was only only 46 years. Such differences existed, if not quite so marked, on comparing all agricultural with city populations in England. The confined life of cities, whereby the population was crowded in tenements with warm moist stagnant air, compared to the open life on the hills, fields, and sea, was a great cause of sickness, loss of vigour, and enjoyment of life.

In proof of that they all knew that exposure naked to the sun and open air had a marvellous curative effect on slum children afflicted with tuberculosis and disease of the spine, and so on, as might be seen at Lord Mayor Treloar's Cripples' Hospital at Alton, under the care of Sir Henry Gauvain, or at Leysin in the Alps, under Dr. Rollier. He would like to show a few photographs just to illustrate how the children lived.

One slide shown on the screen showed the tubecular children naked, exposed to the open air and sun in the galleries. Their heads were carefully shaded, and the exposure of the body was gradual, otherwise the skin would blister. They got as brown as niggers, and their muscles got firm and hard, and their health improved, and their appetite went up. As had been proved lately at Treloar's Hospital by him and his colleagues, the heat production of the body was largely increased by that life in the open air, and that improved the appetite and all the other things, and effected the cure. Nothing was done except putting the limbs or back in splints and exposure to the open air and sun.

Another slide showed the children when they were better, when they could put off their splints, and do haymaking in the summer with nothing on but a loin cloth, and yet another showed the children skating in the Alpine winter with nothing on but a loin cloth. They lived that life, exposed to the sun and the cold air. There was a splendid cold air there which invigorated the muscles, and sent up the bodily heat production, and kept them vigorous, and the sun was keeping them warm and happy all the time by shining on their skin.

Children at Hayling Island from Treloar's Hospital went down to the sea and paddled and bathed every day whenever possible, and that increased the rapidity of cure very greatly indeed.

He would come to the question of measuring the cooling and evaporative power of the air. Dr. Haldane had taken the wet-bulb as the measure, and pointed out that such-and-such a wet-bulb degree must be kept up. That was an exceedingly valuable criterion in confined places. J. L. Bruce in Australia preferred the dew-point rather than the wet-bulb. He (the author) had introduced an instrument called the katathermometer which took into account, not only the temperature, but the wind. The wind was the great thing which was cooling to the body. Too much wind was uncomfortable, but sufficient wind brought comfort.

The rate of cooling was measured between 100° and 95° F., and one took the mean for one's calculations as 36·5° C. (97·7° F.), and that was roughly skin temperature. The cooling power of the air per second was measured at skin temperature per sq. cm. of surface. The cooling power should not be translated straight away to the human body because the kata bulb was a very small thing, half the size of one's thumb, and in the large masses of the body, the limbs and the head and the trunk, the surface exposure compared to the mass was much smaller. The kata gave the cooling of a mouse rather than the cooling of the human body. One could empirically find out what were suitable cooling powers by taking measurements under all kinds of conditions where people were happy and comfortable, and those standards ought to be kept up in all mines, factories, and so on. By putting a muslin glove on to a katathermometer it was converted into a wet instrument and the cooling power by the wet katathermometer was then obtained. The dry one cooled by radiation and convection; the wet one cooled by radiation, convection, and evaporation; and the difference in the reading of the two gave the cooling by evaporation. The dry one represented the skin cool and dry, and the other one represented the skin sweating. The dry one was the more valuable in our factories and workshops, and the wet one was useful in climates, mines, &c., where there was a moist, hot atmosphere.

The cooling power had been studied in winds of different velocity in large wind tunnels at the National Physical Laboratory and at the East London College, and also by rotating the kata on a rotating arm. A diagram in the paper showed what cooling powers were obtained at different

temperatures with different winds. It would be seen that taking 20° C., to get a decent cooling power it would be necessary to have a wind getting on for one mile per hour. In order to get a cooling power of something like 6, which he considered a standard cooling power suitable for sedentary work, it would be necessary to have a wind of one mile per hour. Taking a temperature of 30° C., to get that cooling power it would be necessary to have a higher wind, and so on.

It would be seen what an enormous effect the wind had upon cooling power. That could be seen at once by taking some dry kata observations on different days. There were some given in his paper when the dry-bulb temperature was practically the same on different days, but the wind was very different. In one case it was a strong north wind; in another case it was a south-east wind of a moderate kind, and in another case it was almost calm. The dry kata reading was 56 in the first case, 27 in the second, and 13 in the third case. Clothing, of course, had a big effect upon the cooling powers. The details of the influence of clothing could be found in the second volume of his report on the Science of Ventilation and Open-Air Treatment, which was a special report to the Medical Research Council and could be obtained from His Majesty's Stationery Office.

He had set up a standard of cooling power. The dry kata cooling power ought to be 6, and the wet kata cooling power ought to be 16 or 18—not less than that. He had found that those standards held good in rooms which appeared comfortable and fresh, where people were working quite happily and comfortably. Very often the figures which were obtained in factories were under those standards. A great number of observations had been taken by the Industrial Fatigue Research Board in different factories, and he had given some of those in the paper. For example, in potters' shops generally the dry kata readings were under the standard which he had given on cold days. With regard to warm days the readings were far under the standard which he had given.

A series of diagrams projected on the screen showed the same point. Those observations had been taken in printing shops in London during the previous winter and during the summer. The percentage of observations in different printing shops was given and the degrees Fahrenheit with the dry-bulb temperature.

One of the diagrams showed the wet-bulb temperature in the printing shops winter and summer. It would be seen that the wet-bulb temperature was beating up in the summer, but it was not very high, according to Dr. Haldane's standard. Occasionally it reached 72.

Another slide projected on the screen showed the dry kata and the wet kata. In the winter in printing shops a good many cases occurred where it was below his standard and some were above. He did not think that it mattered up to 8 because the men could work comfortably, but it was getting rather cold when it reached 9. In the summer it was found that readings were as low as 1 in some of the printing shops. Those were very bad conditions. With the wet kata his standard was 18, and in winter many readings were below that, and many more in summer.

The dry katathermometer could be used as an anemometer. They had worked out formulæ, and lately they had been able to thoroughly revise them; they had been able to work in the big wind tunnels, which they could not do during the war owing to the use of them for aeroplane work. They had had to modify their formulæ to some extent. They had never worked out the low velocities previously. It was hard to do that in wind tunnels, but they had done it on the rotating arm. In all that work he was very grateful to Miss Hargood-Ash, who was present that night showing the instruments. She had helped most patiently and excellently in all that work, and they had worked out the formulæ which they had given at the end of the paper. Air velocities could now be calculated quite accurately, he thought, with the katathermometer. In many factories they obtained air velocities which were very poor, even in winter, and poorer still in the summer.

Another slide projected on the screen gave frequency curves, worked out by the Industrial Fatigue Research Board in boot and shoe factories, of velocity as determined by the dry-bulb katathermometer in various methods of ventilation. It showed ventilation by open windows, and ventilation by roof cowls, and skylight windows in the winter and the summer. Then there was ventilation by various artificial methods. The extraction by fan came out the best, giving the highest velocities, and the plenum came out the worst.

Another slide showed the combined plenum and extraction system, such as one might introduce with a fine current sweeping through the mine or factory, so as to keep the evaporative power sufficient to sweep away the dust and sweep away the microbes exhaled by the people. That seemed to be the most ideal artificial form of ventilation.

In South African mines Dr. Orenstein and Mr. Ireland had been using the katathermometer for estimating the effect of atmospheric conditions on output and fatigue, and the diagram showed that output was lowest when the dry kata cooling power was lowest.

Further evidence concerning efficiency was given in his paper.

[Slides were then shown illustrating the electrical katathermometer and the recording electrical katathermometer. These instruments were demonstrated by Miss Hargood-Ash after the meeting.]

Dr. J. S. Haldane said that Dr. Hill had brought forward the subject of ventilation in such a clear and full manner that at first sight it might seem that there was nothing left for him to add. There were a few points, however, on which they did not altogether agree, or on which, at any rate, he thought there was room for discussion. On the whole, however, he was in cordial agreement with a great part of what Dr. Hill had so admirably said.

Dr. Hill had referred to an old report of a Departmental Committee of which he (Dr. Haldane) had been Chairman, on the subject of the standard of carbonic acid in factories, and he had pointed out that the comfort of a room did not depend on the carbonic acid. That was a fact with which he cordially agreed. In fact, he could add volumes to the evidence which Dr.

Hill had given on that subject. Perhaps the evidence from submarines was the most clear. During the war a submarine was often submerged for 20 hours at a time, and for various reasons could not show its nose above water. The air under those conditions got pretty bad chemically; in fact, after a few hours no light would burn in the air, but it was quite comfortable so long as the carbonic acid did not go higher than about 3 per cent. If the carbonic acid went higher, people at rest in the submarine were still quite comfortable, though breathing a good deal deeper than usual; but men working the planes could not do so properly because they were panting. Therefore, it was necessary to keep down the percentage of carbonic acid in the air.

But the air from a chemical point of view was atrocious. If a match was struck it just fizzled and that was all, and a light went out as if you were putting it into water. No one was aware of anything unusual in the air until they saw the effect on a light. An officer entering the submarine as she was opened up told him that the air was like that of a high mountain; he noticed the increase in breathing, but smelt no bad smell and felt nothing unpleasant, and he thought the air was quite good—and so it was with a clean and healthy crew on board. The whole secret was, as Dr. Hill had pointed out, that the place was cool. The sea water kept the submarine perfectly cool, and condensed any excess of moisture there might be on the walls. One could sleep there quite soundly. He had slept there as soundly as he had slept at home.

That was only one more example pointing the moral of what Dr. Hill had said. But coming back to that standard of ventilation, he was not going to agree that that standard, taken in conjunction with the recommendations as to temperature, was not a useful one. A standard of 12 parts per 10,000 of carbonic acid in the air represented a certain moderate degree of freedom from the germs which Dr. Hill laid such stress on in a further paragraph. That standard only represented what was practicable at the time. It was the result of a great many observations in factories in different parts of the country. They were not thinking of whether the air was warm or cool, but of the exchange of air necessary for the purpose of keeping down infection as far as possible. They would have liked to have said that the standard should be a much higher one, but that did not seem attainable. He had served on a committee in the Navy just before the war where they had gone in for a far higher standard because there was no end of power available for ventilation purposes on battleships.

He agreed with nearly all that Dr. Hill had said on the subject of dust, but he thought that there was one point on which perhaps they did not quite agree, and that was as regards the final effect of what Dr. Hill called a harmless dust. He (Dr. Haldane) would call a harmless kind of dust the sort of dust which was present in smoke particles or coal dust, or the shale dust which was inhaled by coalminers to such a large extent. He did not think that habitual inhalation of a moderate amount of that dust did any harm in the long run. At any rate, it appeared to him that the evidence that it did harm and produced a state of chronic asthma or bronchitis was not reliable. He had discussed that matter in a paper several years previously before the Institution of Mining Engineers, and he had analysed the records of the death-rates for different occupations and come to the conclusion that there was no evidence that the dust ordinarily breathed in a coal mine did any harm in the end to the coal miners. He would say the same for the smoke in towns. He did not believe that the smoke in towns injured people's lungs, or at any rate, he did not believe it accumulated in them. People had in their lungs an astoundingly efficient service of phagocytes whose business was to remove solid particles, including bacteria. If that service was given plenty to do it probably became more efficient, and this was perhaps one of the reasons why coalminers, though they were exposed to much dust, had extraordinarily little phthisis. Moreover, they breated not only coal dust, but a large quantity of shale dust containing a third or more of quartz. Probably a coalminer breathed much more quartz than a goldminer. The harmlessness of quartz in a coal mine seemed to depend on its admixture with coal dust, &c., which stimulated the phagocytes to do their work, whereas a perfectly inert dust like quartz unmixed with substances like coaldust did not.

At some places they found miners breathing enormous quantities of silica and quartz with no harm at all. It was mixed with something else which somehow or other led to its being excreted by the lungs so that they did not suffer. It would be seen from that why he did not take much interest in general standards of how many particles of dust should be in the air. It all depended on the kind of dust and the size of the particles. Some kinds of dust were so deadly if they were breathed for long periods, that it was extraordinarily important to keep the air as free from the dust as possible, or else to mix the dust with something which would render it harmless.

Dr. Hill had laid great stress on bad effects from a low cooling power in air. He (Dr. Haldane) frankly said that he did not, provided that men could still regulate their body-temperatures. He believed that a mine, however warm it was up to a certain point, and however moist it was up to a certain point, ought to be a perfectly healthy place, and was so, except where there were other causes of unhealthiness. Dr. Hill had referred to the Cornish miners who suffered very much from miners' phthisis. This was certainly due to the dust, but as to any bad effects of the heat, he really did not think there were any. In the first place, the great majority of them worked in fairly cool places and they suffered from phthisis just the same, and had the same death-rate. In the second place, they found men working coal mines all over the country, under, in many cases, even more trying average conditions of heat than in Cornish mines. There were some fearfully hot places in the Cornish mines certainly, but they were very exceptional.

He did not think it mattered at all as regards heat, whether the men went to cinema shows afterwards. What mattered was what infection

they got there. He thought that a man who was accustomed to heat, and was accustomed to regulating his temperature during hard work, would stand an atmosphere a good deal more warm than a person who was not. If a person were engaged in literary work or something that did not make him sweat, and he was put down into a mine or a fairly warm place, he would get faint or get a bad headache, or even a violent attack of diarrhoea; but if he got accustomed to the warm air he was all right. The same thing applied to miners. If they put a man who was not accustomed to heat into a hot mine it would bowl him over, and he would have to come out. He had to get acclimatised. So far as his observations had gone he did not think it mattered to a man's health whether the air had less cooling power relatively to other places, so long as he could keep his body temperature from going up.

If it were not so, where would they all be if they went to a tropical country, or went to Australia even. With regard to the conditions there during a great deal of the year as measured by the katathermometer, there would be much less cooling power than there was in England, but the people in Australia were very well and vigorous, and they were very well in most tropical countries if they could avoid infection and tropical diseases, and they could work vigorously provided the cooling power of the air was sufficient to enable the body to regulate its temperature during work.

He did not think that the high expectation of life in Westmorland had anything to do with cooling power. He did not see any evidence of it. There were other causes at work. Babies, for instance, in Westmorland, were properly looked after by their mothers in Nature's way. In Middlesbrough they found a very different state, and there was a tremendous death-rate amongst infants, which was now fortunately being tackled all round. A sweeping reduction had been brought about in the last few years in the infantile death-rate. That, at once, put up the expectation of life in a place like Middlesbrough; and all the other conditions could be taken one by one, he thought. He could not believe that it had much to do with the cooling power of the air. He also thought that the existing evidence showed clearly that the pneumonia among natives brought to the Johannesburg mines was not due to underground conditions. It had been dealt with successfully on a quite different theory.

He would like to say something about the significance of the wet-bulb temperature. First of all with regard to taking the dew-point as a guide. Dr. Hill had mentioned that an Australian investigator regarded the dew-point as a better guide than the wet-bulb, and had fixed 62 as the permissible maximum dew-point. If that was the permissible maximum all he could say was that that permissible maximum was very constantly being exceeded, and they could not help its being exceeded. But if anyone said that the dew-point could be taken as a guide he would be inclined to pay as much attention to him as if he argued that the earth was flat. This was because such an idea was entirely contrary to evidence of the most definite kind and to the whole physics of the subject. He did not want anyone to go away thinking there was any doubt on this subject; there was none.

Then with regard to the katathermometer. That was an instrument which, as Dr. Hill had so clearly explained, told one the cooling power of the air; and he thought it was an admirable scientific instrument for that purpose. It took into account the movement of the air, the wet-bulb temperature, the dry-bulb temperature, and everything else all in one sweep. Dr. Hill had said that he (Dr. Haldane) was rather inclined to take the wet-bulb as a more useful guide. So he was, on the whole. He thought the reason would be evident to anyone who had to do practically with looking after the temperature and the working conditions in mines. The reason was that taking, for instance, a working face in a coal mine, some of the men were in a good air current, some were holing the coal under the seam and were out of the air current, and the air current varied very much in different parts. If the reading of the katathermometer were taken in the air current they would get one reading, and if it were taken underneath the coal where the men were holing, they would get another reading.

He thought that the wet-bulb temperature gave them on the whole a more useful indication of the conditions. In any case it was necessary in order to be able to control the conditions to find out what was wrong when the katathermometer indicated that something was wrong. It was necessary to know what the dry-bulb temperature was and particularly what the wet-bulb temperature was. That was the only reason why he was inclined to lay very great stress on wet-bulb readings, although the katathermometer gave everything together and gave the whole effect. There was one thing he desired to say with regard to both wet-bulb temperature and katathermometer readings. They seemed to him to be of little direct significance in mines until they were getting near the point at which the body was unable to regulate temperature any further.

If men were put to work where the wet-bulb was too high or the wet-bulb *plus* the air current were not satisfactory, the only thing that happened was that they would not work. Miners knew quite well what they were doing. The only instances in which he knew of direct harm to them through heat were cases where men had gone on working through some urgent necessity in temperatures in which they would not work ordinarily; for instance, in rescue work. In the case of saving life they would risk their lives, but they would not risk their lives for the purpose of getting mineral. It was necessary to see that the conditions were such that the men could do full and efficient work, and unless they were pushing physiological means of regulation too hard there was not much difficulty.

The Committee of the Institution of Mining Engineers had come to that conclusion as regards mines in England: that there was no difficulty with proper ventilation in keeping the conditions such as would enable them with proper ventilation to go far deeper in coal mines than at present. In the Transvaal it was very much easier because of the very much lower geothermic gradient than in this country. The ventilation could be regulated so that a man's body temperature did not go up, and he submitted that as long as that was so the man's life ought to be perfectly healthy—and he believed it was. At any rate he would

like to have more evidence than had been brought before them to show the contrary.

Mr. Robert McLaren, M.P., said that as a visitor he would like to say that it had given him very great pleasure indeed to listen to Dr. *Hill's* paper. With a great deal that had been said he was in entire agreement, but what he noticed in connection with all scientific societies was that sometimes they forgot the practical side. The instrument on the table which had been *shown upon the screen was an excellent instru*ment, but the difficulty that he had was that hundreds of them would be required in some of the large mines to indicate exactly the conditions of the mines as far as ventilation was concerned. He was also reminded when he saw that instrument of one which he had invented himself which was going to do great things, but when they took it down the mine they found that it was not only costly, but that it did not come up to what they had expected. For that reason he had very little faith in instruments used underground ever since.

Dr. Haldane had spoken very clearly on the question of the ventilation of those mines which concerned him (Mr. McLaren) most of all. He could, from the practical side, corroborate what Dr. Haldane had said with regard to the miners who swallowed a good deal of coal dust. Many years previously when he was a younger man it used to be said about men living in his district, which was a mining district entirely, that they died very soon through asthma of phthisis because of the *swallowing of coal dust*. When Dr. Haldane gave it forth to the world that coal dust after all did not affect the miners' lungs, but was sometimes a help to the miners, it was no surprise to him to learn it, because in those days the reason why the miners suffered from phthisis was because of the carbonic acid gas given off in the mines, *and the want of ventilation*. In the same district under existing conditions they found men working in the mines who were over 60 years of age, strong and healthy, and evidently the mines agreed with them. Those men, he knew for a fact, swallowed a good deal of coal dust. It was perfectly evident then that the question of ventilation was the first thing that ought to concern he mining managemen of any colliery. Personally, when he used to be a Government Inspector of Mines, he forgave a colliery manager a great deal if he found he provided a good ventilation.

It was perfectly evident to anybody who knew anything about the management of mines that there must be different temperatures throughout the mine. If one took the case of a large mine which extended perhaps for miles, it was apparent that that part of the mine which got fresh air to begin with was relatively fresh and pure and cool, but when one went further in the air became contaminated for various reasons over which no one had any control. There were the gases given off by the coal, and the gases generated by the breathing of the men themselves, and from their lamps.

(To be continued.)

CORRESPONDENCE.

PHARMACY ACTS AMENDMENT BILL.

To the Editor of the Chemical News.

Sir,—I am instructed by the Council of the Institute of Chemistry of Great Britain and Ireland to direct your attention to the following letter which has been addressed to Capt. James O'Grady, J.P., M.P., Col. D. Watts Morgan, D.S.O., M.P., and Mr. Thomas W. Casey, M.P.—I am, &c.

Richard B. Pilcher,
Registrar and Secretary.

November 17, 1921.

Pharmacy Acts Amendment Bill.

Sir,—The attention of the Council of the Institute of Chemistry of Great Britain and Ireland has been directed to "a Bill to regularise the position of all persons trading as chemists and druggists or pharmacy store proprietors in the sale of drugs, the dispensing of doctors' prescriptions, and the sale of medicine."

The official print states that the Bill was presented by Captain O'Grady, and supported by Col. Watts Morgan and Mr. Casey.

In this Bill reference is made to "the Incorporated Society of the Institute of Chemistry" and to "the Institute of Chemistry."

The Institute of Chemisry of Great Britain and Ireland is the only body in this country incorporated by Royal Charter whose title contains the words "Institute of Chemistry," and the Council of the Institute desire me to inform you that they have not been consulted with regard to the provisions of this Bill and have not had any information regarding its promotion.

The Institute of Chemistry is established to examine and register persons found competent to practise chemistry in its applications to the arts and manufactures, as distinct from those who practise pharmacy and are engaged in the sale of drugs and medicines, and in the dispensing of prescriptions.

The Council of the Institute deplore the confusion which arises through the application of the term "chemist" to two distinct callings, and they would welcome any legislation which would tend to remove this confusion.

They hold that the use of the distinctive titles "chemist" and "pharmacist" to denote these callings would tend to the general recognition of the difference between them and to the removal of a confusion which exists in no other country.

The Council wish to dissociate themselves from the suggestion that they should be represented on the Central Council, which it is proposed in the Bill shall be concerned with the Pharmaceutical Register, and from taking any part in the examination and registration functions vested by Royal Charter and the Pharmacy Acts in the Pharmaceutical Society of Great Britain. The Council do not feel called upon at present to comment upon the other provisions of the Bill.—I am, &c.,

(*Signed*) Richard B. Pilcher,
Registrar and Secretary.

NOTES.

Royal Institution.—A General Meeting of the Members of the Royal Institution was held on the 5th inst., Sir James Crichton Browne, Treasurer and Vice-President in the Chair. Mr. A. K. Loyd was elected a Manager to fill the vacancy caused by the death of Mr. J. H. Balfour Browne; Dr. Niels Bohr (Copenhagen), Dr. Johan Hjort (Copenhagen), and Prof. Paul Langevin (Paris) were elected Honorary Members; and Mr. W. A. F. Balfour Browne, the Dowager Countess of Carnarvon, Mr. P. C. Clifford, Mr. and Mrs. C. L. Dalziel, Major F. R. de Bertodano, Lieut.-Col. F. J. Dewes, Mr. H. J. Eck, Mr. K. Lightfoot, Mr. W. M. Ogilvie, Mr. R. B. Ransford, and Mr. F. I. Rawlins were elected Members.

We understand that the State Electricity Commission of Australia has given to a Wolverhampton firm what is possibly the largest order undertaken in this country. The summary of the contract is as below, and it has been secured in spite of severe American competition, and certainly indicates a revival of trade. "Twelve 'Thompson' Patent Straight Vertical Water-Tube Boilers, working pressure 260lb. per sq. inch each to evaporate 70,000lb. of steam per hour, fitted with superheaters to superheat the steam to a final temperature of 650° F. Each boiler will be fitted with three Underfeed Forced Draught Travelling Crate Stokers to burn Morwell Brown Coal. This coal, we believe, is found practically on the earth's surface, and the Power Station is being erected adjacent into the fuel bed, and is for the purpose of supplying power to Morwell and district. The boilers will be complete with chimneys, flues, and automatic soot and ash extracting and disposal plant."

Board of Trade Announcement.—The Board of Trade give notice that in exercise of the powers conferred upon them by Part II. of the Safeguarding of Industries' Act, 1921, they have referred to a Committee constituted for the purposes of that part of the Act and consisting of: Sir William Ashley, Ph.D. (Chairman); Mr. J. Arthur Aiton, C.B.E.; Sir Thomas W. Allen; Sir John N. Barran, Bt.; and Mr. F. R. Davenport; a complaint by the British Flint Glass Manufacturers' Association and the National Flint Glass-Makers' Society, that articles of domestic glassware, illuminating glassware, and mounting glassware, manufactured in Germany and Czecho-Slovakia, are being sold or offered for sale in the United Kingdom at prices which by reason of depreciation in the value in relation to sterling of the currency of the above-named foreign countries are below the prices at which similar goods can be profitably manufactured in the United Kingdom, and that by reason thereof employment in the glass industry in the United Kingdom is being or is likely to be seriously affected. The Commitee are directed after ascertaining the facts to report to the President of the Board of Trade (*a*) whether the conditions specified in Section 2, Sub-Section (1) of the Safeguarding of Industries Act, 1921, are fulfilled; (*b*) on the effect which the imposition of a duty under Part II. of the Act on goods of the class or description covered by the complaint would exert on employment in any other industry being an industry using goods of that class or description as material; and (*c*) whether in the opinion of the Committee production in the industry manufacturing similar goods in the United Kingdom is being carried on with reasonable efficiency and economy. The Committee propose to hold their first sitting for the taking of evidence at 2.30 p.m. on Monday, December 12, 1921, at the Hotel Windsor, Victoria Street, London, S.W.1. The Secretary to the Committee is Mr. W. G. Fergusson, Board of Trade, Great George Street, London, S.W.1, to whom all communications should be addressed.

We have received from the Secretary and Editor of the Faraday Society a copy of the "Report of a General Discussion on Electrodepositions and Electro-plating" that resulted from a joint meeting of the Faraday Society and the Sheffield Section of the Institute of Metals, on Friday, November 19, that was in the Sheffield University. The Report, which is well printed and illustrated, will form a very valuable reference book on the technicalities of electrodeposition; the papers are of exceptional interest, and deal exhaustively with the subject and include electroplating as prevention of corrosion, deposition of cobalt, gold-silver alloys, the use of colloids in the electro-deposition of metals, crystalline structure of electro-deposited silver, and many kindred matters, together with discussions by those present at the meeting. We have already drawn attention to the valuable work that is being done by the Faraday Society in arranging and publishing these important discussions, and we append a list of the papers that can be obtained by application to the Secretary, 10, Essex Street, W.C.2, and prices. The Microscope: Its Design, Construction and Applications (bound in cloth), 21s. The Present Position of the Theory of Ionisation, 12s. 6d. Occlusion of Gases by Metals, 5s. The Co-ordination of Scientific Publication, 3s. Electric Furnaces, 3s. 6d. The Setting of Cements and Plasters, 5s. 6d. The Training and Work of the Chemical Engineer, 3s. 6d. The Attainment of High Temperatures in the Laboratory, 2s. 6d. The Transformations of Pure Iron, 2s. 6d. The Passivity of Metals, 3s. 6d. The Constitution of Water, 2s.

Queensland Mineral Pigments.—Mr. Joseph Campbell, an Australian scientist, has devoted three months to a special study of the triassic rocks lying to the north of Cooktown, Queensland. These rocks yield, among other things, valuable oxides and ochres, and at Cape Flattery in particular there is scope for a large industry in pigments. Last year Australia imported 1,636 tons of dry colours of all tints, valued at £85,990. Cape Flattery alone can produce a large proportion of such pigments at a much lower cost than that at which they are imported. A sample of red oxide (Indian red) from this source was found by the Government Analyst of Queensland to contain the following percentages: Loss on ignition (*i.e.*, moisture, 7·3; silica and insoluble, 23·2; oxide of iron, 61·4; alumina, 8·0; total, 99·9. It is interesting to compare this with the following analysis of an ordinary Indian red: ferric oxide, 43·82; alumina, 28·30; silica, 23·16; calcium carbonate, 3·15; loss on ignition (water) 1·45; total, 99·88 per cent. If calcium carbonate is required in the Cape Flattery red, it is easy to supply it from the coral reef around, which can be pulverised for the purpose.

New Patents

This List is specially compiled for the *Chemical News* by Messrs. Rayner & Co., Registered Patent Agents, of 5, Chancery Lane, London, W.C.2., from whom all information relating to Patents, Trade Marks and Designs can be obtained gratuitously.

Latest Patent Applications.

30124—Commin, F. H.—Process for fixation of atmospheric nitrogen November 11

30471—Barrett, Co.—Process for purification of hydrocarbons. November 15

30520—Morris, E. F.—Electrolysis of acetone solutions. November 16

30612—Imray, O. Y.—Manufacture of derivatives of dihydro-isoquinoline. November 16

30691—Rigby, T.—Utilization of industrial waste products November 17

Specification published this Week.

142806—Barrett, Co.—Manufacture of resin from naphthas

170880—Matheson, E.—Manufacture of sulphuric acid

146407—Berger, H.—Manufacture of an improved nickel catalyst

170991—Wolffenstein, R.—Production of solutions containing aluminium formate and an alkali-salt

170964—Bronnert, E.—Process for production of high-percentage sulphite cellulose

Abstract Published this Week

Sulphur-terpene Compounds.—Patent No. 169513.—Terpenes, or certain derivatives such as terpineol, or rosin are heated with sulphur to produce brittle solids, or semi-solids according to the duration of the heating; sulphuretted hydrogen is evolved. In an example, equal parts of oil of turpentine and sulphur are heated together for three hours at a temperature rising from 150-200° C., yielding a neutral brittle mass soluble in turpentine, toluene, and xylene; the quality of gas evolved may serve as a check on the progress of the reaction. The products from non-colloidal solutions and may be used, either alone or in toluene, xylene, etc. solution with or without addition of rubber, for coating or impregnating materials, they may also be vulcanized on to or with rubber and can be moulded. If a semi-solid product is employed, further heating effects conversion to the harder products; for example, if mixed with wood pulp and heated in a press, a hard solid mass results.

Messrs. Rayner & Co., will obtain printed copies of the published specifications and will forward on post free for the official price of 1/- each.

MEETINGS FOR THE WEEK

Monday, December 12.

Royal Society of Arts, 8. "Processes of Engraving and Etching," by Arthur M. Hind

Tuesday, December 13.

Chemical Society, 7.45. (Annual General Meeting). "Structure of some Gaseous Molecules. by Prof. A. O. Rankine

Wednesday, December 14.

Royal Society of Arts, 8 "Trade with the Netherlands, East Indies," by Sir Walter B. Townley

Thursday, December 15.

Chemical Society, 8. "Researches on Residual Affinity and Coordination," by G. T. Morgan and J. D. Main Smith

Institution of Electrical Engineers, 6. "Induction-Type Synchronous Motors," by L. H. A. Carr

YOUTH, 17. Matriculated, wants position in Laboratory while continuing evening study. Willing and and trustworthy. DENINGTON, 69, Dover Road, London, E.12

PATENTS, TRADE MARKS. Handbook and advice free—B. T. KING, British and U. S. Regd. Patent Attorney, 146a, Queen Victoria St., London. 35 years reference

NOTICES.

EDITORIAL.—All Literary communications and Books, Chemical Apparatus, &c., for review or notice to be addressed to the EDITOR.

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THE CHEMICAL NEWS.
VOL. CXXIII., No. 3218.

INDUCED REACTIONS AND NEGATIVE CATALYSIS.*

By N. R. DHAR and N. N. MITTRA

If A and B chemically react with one another, while A and C do not under ordinary conditions, but do so in the presence of the former reaction, the second reaction is said to be induced by the first; in other words, a chemical change between one set of substances is capable of forcing or inducing a chemical change between another set of substances having the potentiality to undergo a chemical change. For instance, when an acqueous solution of mercuric chloride is boiled with oxalic acid, there is no reduction of the mercuric chloride to the mercurous state, but as is well known this mixture of mercuric chloride and oxalic acid decomposes at the ordinary temperature in sunlight according to the equation :—

$$2HgCl_2 + H_2C_2O_4 = 2HgCl + 2HCl + 2CO_2.$$

The same change, however, takes place in the dark (Dhar, *Jour. Chem. Soc.*, 1917, cxi., 690) if a few drops of a decinormal potassium permanganate are added to the mixture; as soon as the colour of the permanganate is discharged mercurous chloride begins to separate out.

This phenomenon appears to be of general occurrence. Thus it has been found out that the reduction of mercuric chloride and bromide by oxalic acid, tartaric acid, citric acid, malic acid, malonic acid, glycollic acid, cane sugar, grape sugar, glycerine, lactic acid, hydroxylamine hydrochloride, hydrazine hydrochloride, &c., the reduction of gold chloride by several reducing agents, and the reduction of silver nitrate, cupric chloride and selenious acid (to selenium) by various organic acids are promoted by the addition of such oxidising agents as potassium permanganate, potassium persulphate, manganese dioxide, potassium nitrite, hydrogen peroxide, ceric salts, &c. (Dhar, *Proc. Akad. Vetensk*, Amsterdam, 1921, xxiii., 1074).

It is a remarkable fact that this effect is particularly noticeable in those reactions, which are very sensitive to light.

To investigate further the general occurrence of induced reactions, the following cases have been studied.

According to the customary nomenclature, the faster reaction is called the primary reaction and that which appears to be forced along or induced by contact with the primary change is called the secondary reaction. The substance which takes part in both reactions is called the actor, the substance which takes part in the primary reaction is called the inductor, and the substance which takes part in the secondary reaction is called the acceptor. The way in which the inductor acts is not known, and hence these induced reactions form a branch of catalysis (see Table I.).

In all the above-mentioned cases at first the primary change, that is, the oxidation of the easily oxidisable substance takes place and this primary change induces or promotes the secondary or the induced change, that is the oxidation of the difficultly oxidisable substance.

In several of these induced reactions we determined the induction factors, but unfortunately hardly any conclusion could be drawn from these induction factors as to the mechanism of these changes.

It is well known that a solution of sodium arsenite is not oxidised by atmospheric oxygen under ordinary conditions. On the other hand, a solution of sodium sulphite is readily oxidised to sodium sulphate.— Now if we mix the two together, both the oxidations go on simultaneously. At the same time a curious phenomenon takes place. The velocity of the oxidation of sodium sulphite becomes very small in presence of sodium arsenite, that is, sodium arsenite which is undergoing a slow oxidation acts as a powerful negative catalyst in the oxidation of sodium sulphite. Similarly a solution of oxalate which also undergoes slow oxidation in presence of sodium sulphite, which is itself being oxidised, slows down to a marked extent the oxidation of sodium sulphite by atmospheric oxygen. Moreover, we have observed that manganous hydroxide, ferrous hydroxide, and sodium thiosulphate which are slowly oxidised by passing oxygen in presence of a solution of sodium sulphite markedly retard the oxidation of sodium sulphite. Also ferrous salts retard the oxidation of stannous salts in air. It appears probable, therefore, that the phenomenon of negative catalysis is possible only when the catalyst is liable to be oxidised. These cases are of great importance in connection with the controversial question of negative catalysis.

In a previous paper (Dhar, *Jour. Chem. Soc.*, 1917, cxi., 707) it has been shown that manganous salts act as powerful negative catalysts in the oxidations of formic and phosphorous acids by chromic acid, and manganous salts can easily pass into the manganic state. Moreover, it has been shown by various investigators that some organic substances notably quinol, brucine, &c., act as negative catalysts in the oxidation of sodium sulphite by oxygen, and all these organic substances are themselves readily oxidised. It is well known that the oxidation of phosphorus by oxygen of the air is retarded by the vapours of various organic substances, *e.g.*, ether, alcohol, turpentine, &c., and the oxidation of chloroform is retarded by the presence of a small quantity of alcohol. Now all these negative catalysts are good reducing agents, and are themselves readily oxidised. Hence in oxidation reactions the phenomenon of negative catalysis takes place when the catalyst itself is liable to be readily oxidised.

If we expose a mixture of sodium sulphite and sodium arsenite to atmospheric oxygen, according to Schönbein (*Jour. Prakt. Chem.*, 1858, lxxv., 99) one atom of oxygen should go to oxidise sodium sulphite, while the other atom would oxidise a molecule of sodium arsenite in the same time. The oxidation of sodium arsenite is a very slow chemical change and in order that Schönbein's law be applicable, it follows immediately that the oxidation of sodium sulphite which is fairly rapid, should become a slow change, and the velocity of this oxidation should become equal to that of the

*Read before The Faraday Society, November 28, 1921

TABLE I.

Primary change	Secondary change	Actor	Inductor	Acceptor
$HgCl_2+Na_2SO_3$	$\rightarrow HgCl_2+Na_3AsO_3$	$HgCl_2$	Na_2SO_3	Na_3AsO_3
$HgCl_2+H.COOH$	$\rightarrow HgCl_2+Na_3AsO_3$	$HgCl_2$	$H.COOH$	Na_3AsO_3
$HgCl_2+Na_3PO_3$	$\rightarrow HgCl_2+Na_3AsO_3$	$HgCl_2$	Na_3PO_3	Na_3AsO_3
$HgCl_2+Na_2SO_3$	$\rightarrow HgCl_2+H_3AsO_3$	$HgCl_2$	Na_2SO_3	H_3AsO_3
$HgCl_2+Na_3PO_3$	$\rightarrow HgCl_2+H_3AsO_3$	$HgCl_2$	Na_3PO_3	H_3AsO_3
Na_2SO_3+air	$\rightarrow NaNO_2$+air	air	Na_2SO_3	$NaNO_2$
Na_2SO_3+air	$\rightarrow K_2C_2O_4$+air	air	Na_2SO_3	$K_2C_2O_4$
Na_2SO_3+air	$\rightarrow Fe(NH_4)_2(SO_4)_2$+air	air	Na_2SO_3	$Fe(NH_4)_2(SO_4)_2$
$Na_2SO_3+O_2$	$\rightarrow Fe(OH)_2+O_2$	O_2	Na_2SO_3	$Fe(OH)_2$
$Na_2SO_3+O_2$	$\rightarrow Co(OH)_2+O_2$	O_2	Na_2SO_3	$Co(OH)_2$
$Na_2SO_3+O_2$	$\rightarrow Ni(OH)_2+O_2$	O_2	Na_2SO_3	$Ni(OH)_2$
$Na_2SO_3+O_2$	$\rightarrow Cu_2+O_2$	O_2	Na_2SO_3	Cu_2O
H_2SO_3+air	$\rightarrow FeSO_4$+air	air	H_2SO_3	$FeSO_4$
H_2SO_3+air	$\rightarrow SnCl_2$+air	air	H_2SO_3	$SnCl_2$
$Fe(OH)_2+O_2$	$\rightarrow Ni(OH)_2+O_2$	O_2	$Fe(OH)_2$	$Ni(OH)_2$
$Co(OH)_2+O_2$	$\rightarrow Ni(OH)_2+O_2$	O_2	$Co(OH)_2$	$Ni(OH)_2$
$Mn(OH)_2+O_2$	$\rightarrow Ni(OH)_2+O_2$	O_2	$Mn(OH)_2$	$Ni(OH)_2$
$Ce(OH)_3+O_2$	$\rightarrow Ni(OH)_2+O_2$	O_2	$Ce(OH)_3$	$Ni(OH)_2$
Na_2SO_3+air	$\rightarrow Na_3AsO_3$+air	air	Na_2SO_3	Na_3AsO_3
Na_2SO_3+air	$\rightarrow Mn(OH)_2$+air	air	Na_2SO_3	$Mn(OH)_2$
Na_2SO_3+air	$\rightarrow Na_2S_2O_3$+air	air	Na_2SO_3	$Na_2S_2O_3$
$SnCl_2$+air	$\rightarrow Fe(NH_4)_2(SO_4)_2$+air	air	$SnCl_2$	$Fe(NH_4)_2(SO_4)_2$

oxidation of sodium arsenite, because the same amount of oxygen will be taken up by the reducing agents in the same time. As a matter of fact, from our experiments we have observed that in the presence of sodium arsenite, or potassium oxalate, or manganous hydroxide or ferrous hydroxide, the velocity of the oxidation of sodium sulphite by air becomes very small. We assume that a molecule of oxygen splits up in this reaction into two atoms and each atom oxidises one of the reducing agents. Now as a solution of sodium sulphite is much more readily oxidised than a solution of sodium arsenite, it becomes difficult to understand why the other oxygen atom, instead of attacking the readily oxidisable unacted sodium sulphite, attacks the much more difficultly oxidisable sodium arsenite. Or if we assume that at first a peroxide of the type of Bodländer's benzoyl peroxide (Ahren's *Sarum*, 1899, iii., 470) is formed as a combination of the sodium sulphite with a molecule of oxygen, we are still encountered with the same difficulty. In this case we will have to assume that this peroxide instead of attacking the readily oxidisable unattacked sodium sulphite will attack the less readily oxidisable sodium arsenite by preference. It seems therefore, that the only course left to us is to find out the explanation in the view of the formation of a complex of sulphite and arsenite, or of sulphite and oxalate, and that this complex is oxidised as a whole. It is well known that complex oxalates and sulphites do exist.

It has been observed in a previous paper (Dhar, *Proc. Akad. Vetensk.*, Amsterdam, 1920, xxiii., 299) that in the oxidation of sulphites and sulphurous acid, the sulphite ion is the active agent. On the addition of an arsenite to a sulphite, a complex, which it self is oxidised as a whole, is formed. At the same time the velocity of the oxidation of the sulphite becomes less due to the decrease in the concentration of the sulphite ions arising out of the formation of a complex of sulphite and arsenite or oxalate. Hence it seems that the only plausible explanation of the negative catalysis stands on the hypothesis of the formation of an intermediate complex compound.

Now there is no chemical change between potassium oxalate and mercuric chloride in the dark at the ordinary temperature, though the following chemical change takes place in light,

$$k_2C_2O_4+HgCl_2=2HgCl+2kCl+2CO_2.$$

If to this mixture of oxalate and mercuric chloride we add a ferrous salt, one gets a slight precipitate of ferrous oxalate, and at the same time mercurous chloride is formed. A solution of ferrous salt cannot reduce mercuric chloride at the ordinary temperature, but in presence of an oxalate it becomes a better reducing agent and reduces mercuric chloride to the mercurous state, and at the same time the potential reducing power of an oxalate is activated in bringing forth the reduction of mercuric chloride to the mercurous state. Evidently the reducing power of the ferrous salt as also that of the oxalate is activated by their mutual presence. Tartrates and citrates behave in a similar manner in presence of ferrous salts. Ferrous and ferric salts accelerate the formation of mercurous chloride from an oxalate and mercuric chloride solution when exposed to light. Winther (*Zeit. Wiss. Photo Chem.*, 1909, vii., 409) has brought forward argument to show that the light sensitiveness of a mixture of an oxalate and mercuric chloride is due to the presence of iron, and this investigator suggests that the purest mixtures of an oxalate and mercuric chloride so far prepared have contained iron. In absence of iron the mixture is not sensitive to visible rays. It seems to us that the real function of iron, if it is present, is that of a photoferment or photo catalyst as suggested by Winther, as well as that of an inductor. The ferrous salt in presence of an oxalate reduces the mercuric chloride to mercurous state, and at the same time activates the potential reducing power of the oxalate in indcing the reduction of mercuric chloride to the mercurous state. This induced reaction takes place also in the dark.

On investigating these various cases of induced reactions we were naturally led to the more general conclusion that one chemical change should induce another chemical change of the same type, and we tried to verify this conclusion.

We found that the reduction of mercuric chloride by such different reducing agents as formic acid, sulphurous acid, phosphorous acid, &c., induce in all cases the reduction of the same substance, *e.g.*, mercuric chloride, by sodium arsenite. We also investigated other changes, as for instance, the decomposition of unstable substances. It is well known that ammonium dichromate decomposes readily into nitrogen, water and chromium oxide, also the decomposition temperature of potassium persulphate is lower than that of potassium chlorate, and it has been found that in presence of decomposing ammonium dichromate or persulphate the decomposition temperature of potassium chlorate is appreciably lowered. In this connection it will be of interest to investigate whether the presence of an easily decomposable explosive will lower down the decomposition temperature of a difficultly decomposable explosive, and this investigation will throw light on the velocity of mixed explosives. Farmer (*Jour. Chem. Soc.*, 1920, cxvii., 1432, 1603) has recently shown that the velocity of decomposition of high explosives becomes greater in presence of another explosive which is more readily decomposed. As far as our experiments go, we are inclined to the view that one chemical change will either promote or induce another chemical change of the same nature.

Summary.

(1) The phenomenon of induced reaction is experimentally proved to be of general occurrence.

(2) In oxidation reactions, the phenomenon of negative catalysis takes place when the catalyst is liable to be readily oxidised.

(3) The explanation, of the negative catalysis investigated in these oxidation reactions, seem to stand on the hypothesis of the formation of intermediate compounds.

(4) Experimental evidence has been brought forward in support of the view that one chemical change will either promote or induce another chemical change of the same nature.

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Muir Central College,
Allahabad, India

THE OCCURRENCE OF CALCIUM OXALATE IN THE GIDGEE WATTLE (*ACACIA CAMBAGEI*, BAKER).*

By THOS. STEEL

REFERENCES in literature to the occurence of calcium oxalate in plants are numerous, but records of the amounts present are comparatively scarce. A few of the more important of the latter may be noted. In 1877, W. M. Hamlet and C. R. Plowwright (CHEMICAL NEWS, 1877, xxxvi., 93; *Jour. Chem. Soc.*, 1877, ii., 796) drew attention to the presence of oxalic acid in a large number of fungi, the acid apparently existing in the free state, as hydric potassium oxalate and as calcium oxalate. *Fistularia hepatica* (86 per cent water) contained 0·08 per cent of total oxalic acid, equal to 0·57 per cent in the dry plant, and equivalent to 0·73 per cent calcium oxalate ($C_2O_4Ca+H_2O$)

The presence of the same acid in small amounts in potatoes and malt is recorded by Siewert (*Jour. Chem. Soc.*, 1883, abs. p. 232). Berthelot and Andre (*Jour. Chem. Soc.*, 1886, abs. p. 734) state that they found 13·9 per cent oxalic acid, which is equivalent to 17·8 per cent calcium oxalate, in the roots (dry) of *Rumex acetosa* (common sorrel). Of the 13·9 per cent oxalic acid, 5·9 was in the soluble state and the remainder insoluble.

H. G. Smith (*Jour. Roy. Soc. N.S. Wales*, 1905, xxxix., 23) in a comprehensive paper describes the occurrence of considerable amounts of calcium oxalate in the bark of numerous species of *Eucalyptus*, the percentages present varying from 0·08 to 10·06 of $C_2O_4Ca+H_2O$ in the dry bark.

The occurrence of the same substance in cinnamon and cassia barks was recorded by J. Hendrick (*Analyst*, 1907, xxxii., 14) who found from mere traces up to 3·5 per cent in commercial samples and 0·62 per cent in one of Ceylon wild cinnamon.

J. Otto (*Jour. Soc. Chem. Ind.*, 1912, xxxi., 411) found from 0·4 to 0·9 per cent calcium oxalate in the young needles of pine trees, while old shoots contained 2·3 per cent, and young larch leaves 0·1 per cent, all in the dry material.

R. T. Baker (*Jour. Roy. Soc. N.S. Wales*, 1917, li., 435), as the result of microscopic examination, detected crystals of the same compound in the cells of a large number of Australian timbers.

Further references to various phases of this subject will be found in the collective indices of the Chemical Society and of the Society of Chemical Industry.

F. B. Guthrie (*Agric. Gazette, N.S. Wales*, 1897, viii., 868) recorded an analysis of the ash of the Gidgee or Stinking Wattle (*A. Cambagei*), showing 90·7 per cent of lime (CaO) and 0·40 per cent potash (K_2O).

Another sample of Gidgee ash offered commerself in 1898, contained a similar large proportion of lime and small one of potash.

Being struck by the probability of this proportion of lime being due to the presence of unusual amounts of calcium oxalate in the plant, I obtained from Mr. Maiden samples of the timber and bark of *A. Cambegei* and submitted them to detailed examination, with the results following.

I have calculated the oxalate as $C_2O_4Ca+H_2O$, following H. G. Smith, cited above, who found this to be the constitution of the oxalate separated mechanically from Eucalyptus bark. The method of determination used was similar to that described by Smith, with the exception that I ignited the oxalate precipitate completely and weighed as CaO.

Timber and Bark or Acacia Cambegei.

(Calculated to dryness).

	Outer bark	Inner bark	Outer wood (white)	Inner wood (dark)	Average wood
Ash soluble in acid	8·48	8·43	3·28	2·53	2·86
Sand ... ... 1·15	0·44	0·00	0·00	0·00	0·00
Potash (K_2O) ...	0·06	0·06	0·08	0·05	0·06
Total Lime (CaO)	7·22	7·22	2·23	1·46	1·83
Lime as oxalate ...	8·20	8·16	3·08	2·46	2·70
Calcium oxalate ($C_2O_4Ca+H_2O$)	18·82	18·82	5·81	3·81	4·77
Water in air-dried sample	8·80	9·30	9·00	9·20	9·05

These proportions of calcium oxalate in the bark of *A. Cambegei* are the highest I have seen recorded for any plant.

G. Kraus (*Jour. Chem. Soc.*, 1892, abs. p. 1370)

* By favour of the Author, from the Proceedings of the Linnean Society of New South Wales, 1921, vol. xlvi., Part 2, July 27th, 1921.

concludes from the results of experiments on the bark of various trees which contain calcium oxalate in quantity, that this substance constitutes a reserve deposit and is not an excretion, and hat it is redissolved in spring and summer according to the needs of the plant. Branches of *Ribes sanguineum* and other trees varied in their calcium oxalate content with the seasons, the amount present being highest in winter and lowest in spring and summer. The author states that calcium oxalate is certainly liable to solution by long-continued action of an acid circulating liquid like cell sap.

The abstract does not give any details regarding the structure or appearance of the bark examined. I feel more than doubtful about this conclusion. A fall in the oxalate content of the bark during the growing period is more likely to be due to the addition of new bark free from oxalate, than to the solution of the oxalate already deposited. Oxalic acid is usually considered a waste product, harmful to the plant, fixed with lime in order to render it insoluble and harmless, and we know that it is shed in large amount in leaves and bark.

We have seen above that the dead, dry, outer bark of *A. Cambegei* contains the same proportion of oxalate as the inner bark, and even of the latter only a comparatively thin layer may be in metabolic function, in which condition alone it could receive or part with its load of oxalate.

Smith (*Jour. Roy. Soc. N.S. Wales*, 1895, xxix., 325); 1903, xxxvii., 107) concluded in the case of *Orites excelsa*, which he found to contain large amounts of aluminium succinate, that the succinic acid was a waste, poisonous metabolic product, fixed by the plant with the only available base forming an insoluble succinate, in order to get rid of it.

To deteremine in how far the barks of other species of *Acacia* resembled *A. Cambegei* in calcium oxalate content, the barks of a number were examined. Through the courtesy of Mr. Maiden I was provided with these from the collections in the Herbarium Museum at the Botanic Gardens, Sydney. The analysis of this series was made for me by my colleague, Mr. E. F. Vaughan, to whom my thanks are due. All the samples were of mature bark which had become thoroughly air dried.

Percentages in Acacia Barks

(Calculated to dryness).

	1	2	3	4	5	6
Total ash ...	2·01	1·56	3·05	6·80	6·14	6·05
Total lime (CaO)	1·64	0·91	2·63	2·54	4·04	5·60
Lime as oxalate	0·52	0·60	1·67	2·05	2·58	3·42
Calcium oxalate ($C_2O_4Ca+H_2O$)	1·36	1·56	4·36	5·35	6·74	8·92
Water in air-dried sample	11·43	11·75	13·20	9·58	12·88	10·83

In the total ash the lime was ignited to CaO.

1 *A. Cheelii* Blakely; 2 *A. adunca* A. Cunn.; 3 *A. auriculiformis* A. Cunn.; 4 *A. decora* Reichb.; 5 *A salicina* Lindl.; 6 *A. aneura* F.v.M.

As in the case of the Eucalyptus barks examined by H. G. Smith, there is considerable variation in the amount of oxalate present, but in none of the samples is the high percentage in *A. Cambegei* approached. A variable amount of lime is seen to be in combination other than as oxalate. The bark of *A. decora* contained a comparatively large amount of ash insoluble in acid, and was high in iron and alumina, which might be due to admixture with earthy matter, but there was nothing in the appearance of the bark to indicate this.

In a lengthy article on the chemistry of forest trees, by R. Warington in "Watt's Dict. Chemistry" Part I., 1879, viii., 800, a considerable mass of information on the ash constituents of the bark, timber and leaves of trees is collected. A critical examination of this shows clearly that in most of these lime is the predominating constituent, and that there is never sufficient inorganic acid present to fully satisfy the lime and other bases. Throughout the article no specific mention is made of oxalic acid, though it is stated (p. 809) that the carbon dioxide in the ash represents the organic acids with which the bases were originally united, and that the proportion of bases combined in this way is apparently greater in old than in young wood (and bark). In the light of present knowledge, a study of the data given strongly indicates the presence, in many of these timbers and barks, of very considerable proportions of calcium oxalate.

A NEW CYANIDE.*

By W. S. LANDIS

SOME thirty years ago the new use of cyanide in the gold industry brought to the attention of the chemical world the necessity of producing this material on a larger scale than had been previously done, and at the same time of finding cheaper methods of preparation if the compound was to find an extended use. American, French, English, and German chemists attacked the problem most energetically and from their work arose the present-day processes, which, as far as they have become commercially practicable, you are probably familiar.

Two German chemists, working on the barium carbonate process twenty years ago, attempted to supplant the expensive barium salt with a cheaper calcium salt, and obtained a new product, cyanamid, which afterwards formed the basis of development of the well-known "cyanamid process." To a certain extent they were disappointed at the outcome of their work as the new product calcium cyanamid had little in common with the object of their search and after its discovery they sought for many years to convert cyanamid into cyanide. Their first patents on this tranformation of cyanamid into cyanide were taken out eighteen years ago, these patents covering a process of fusing crude cyanamid with common salt in the proportions preferably of one part of cayanamid to two parts of sodium chloride. The mixture of cyanamid and suitable chloride was to be heated to fusion and until foaming of the mass ceased, which operation was reported to require from one-half to one hour. The resulting product was reported to contain cyanide of calcium, but no analyses were given.

* A paper presented at a meeting of the New York Section of the American Electrochemical Society in Boston, April 8, 1920.—*Transactions of the American Electrochemical Society*, 1920, xxxviii.

In attempting to carry out this process on a commercial scale, apparently they met with a great deal of difficulty. I visited their plant in 1914, and found a great many types of equipment had been installed at one time or another, none of which had worked successfully, and the cyanide plant had been closed down and abandoned for some years.

The earliest type of apparatus consisted of a row of iron crucibles set in a gas-fired furnace with the top flush with the roof of the furnace. These crucibles were about 48in. (122 cm.) deep and 20in. (51cm) in diameter and had been made at various times of cast iron, cast steel, and welded soft steels. In operation salt was melted in the pot and cyanamid was then stirred in and the whole mass kept fused for a suitable length of time. The transformation efficiencies were extremely low, but no actual record of the same was made public.

The next development consisted in setting two iron crucibles side by side in the furnace. In the one crucible they charged salt and melted it, and in the second they charged cyanamid and heated the same to redness. Molten salt was ladled from the first crucible to the second crucible, and when a proper quantity had been added the whole mass was kept melted until by chemical analysis the maximum yield of cyanide had been attained. The contente of the pot were then ladled out and cast into slabs.

The enormous amount of hand labour involved in this operation rendered it commercially impracticable, and a new equipment replaced the old. A revolving furnace was constructed with an enlarged melting hearth midway between the tires. Salt wa smelted in this hearth and tapped into an iron ladle and conveyed to a crucible containing red-hot cyanamid. This operation was also unsuccessful in that there was very considerable wear and tear on the salt melting furnace, and further great care had to be exercised in pouring the molten salt on to theheated cyanamid, as the initial reaction was very violent and the pot frequently boiled over.

The maintenance of the externally heated crucible at the required high temperature became quite burdensome, and a new type of furnace was developed in which an iron pot, provided with a spout, was set into a fuel-fired furnace. This pot was built of welded flange steel. It was 3ft. (0·92 m.) deep and 2½ft (0·76 m.) in diameter. There was also provided an electrode 5in. (12·7 cm.) square and hung on a chain block in line with the axis of the pot so that it could be lowered into the fused mass contained in the same. In this way a single-phase furnace using about 40 volts and 1200 amperes was made in a setting also provided for initial fuel firing. In operating cyanamid was charged into the bottom of the pot and heated to redness by the fire underneath. Salt was melted in the rotating furnace above described, and was slowly poured into the electric furnace at such rate that no very violent reaction ensued. The carbon electrode was then lowered, the current turned on, and the whole mass kept heated electrically until the reaction was complete. The cyanide was tapped through the spout and cast into slabs.

This furnace and process was not successful—the efficiency of nitrogen transformation was very low and the final product contained a comparatively small percentage of cyanide. I was informed, however, that the same type of furnace was successfully being used in another part of Germany, where the salt was melted electrically, and there was being turned out in this second plant a grade of product containing 40 per cent equivalent potassium cyanide at an efficiency of nitrogen transformation of over 90 per cent. I accordingly visited this other plant, and was very much surprised to find there an entirely different type of apparatus in use.

At this second place I found they had tried the combined fuel-fired and electric furnace just described, and had come to the conclusion that the uneven distribution of electric energy throughout the bath caused very uneven heating of its contents, and which was believed to be the cause of the very poor efficiency obtained from the process. The iron pot would only last two or three runs before cracking, and they had abandoned this type of apparatus for a resistance type of electric furnace built of brick. This improved furnace was of the tilting type with a rectangular hearth and arch roof and lined with magnesite brick. The side walls were formed of carbon blocks and electrically connected with a source of current. In practice these blocks were short-circuited with a rod of carbon, and salt was thrown into the furnace and melted around the rod, thus establishing a path of current between the side electrodes. The furnace was then filled with salt. Cyanamid was then added to the melted bath and the heating continued until by chemical analyses the maximum content of cyanide had been formed, when the molten bath was poured out and cast into slabs. I witnessed several operations of this furnace, and found that the furnace produced about 400 kilogrms. of molten product in from three to four hours. The apparatus used about 21 volts and 2800 amperes. The equivalent potassium cyanide in the final product ran from 8¾ to 17½ per cent in the various runs and the nitrogen transformation efficiency from 40 to 75 per cent. During the last run I witnessed, the furnace became blocked with a white spongy material, and all operations were abandoned.

It is thus apparent that in the 15 years elapsing between the initial experiment and my visit the Germans had been able to do little or nothing with the process of transforming cyanamid into cyanide. They had tried out many types of furnaces none of which were successful in any marked degree and had produced only a small amount of product of comparatively low grade and at great inefficiency. They were firmly convinced that it would be necessary to use more than two parts of salt to one part of cyanamid in order to make reaction take place at all and that for smooth working at least three parts of salt to one of cyanamid was absolutely necessary, also premixing of the charge was wrong chemically and must not be used. On the basis of these mixtures the final product should test between 15 and 20 per cent of equivalent potassium cyanide. There were many theories and ideas advanced on the subject, but I could find no comprehensive chemical study of the process and little information of scientific value. In fact, the outlook for this transformation was most discouraging.

In the late fall of 1916 there was a sharp advance in the price of cyanide in this country, and a great shortage in the available supply. The gold and silver mills of the Continent faced a serious situation, and finally one of the large users of the material came to the American Cyanamid Company with a request that it endeavour to co-operate in producing the necessary requirements of this material. With the discouraging report on the German process in hand, and no time available for experimental work, the outlook was not particularly bright, but the problem was attacked and a plant was designed and equipped using resistance furnaces of a modified design, and the older German procedure was altered somewhat with the hopes of obtaining at least results as good as the Germans had anticipated.

This plant was put into operation at Niagara Falls late in December, 1916. It was provided with five resistance furnaces of a tilting type, and two salt melting furnaces of fixed type. While completing the salt-melting furnaces, the resistance furnaces were put into operation as combined salt melting and reaction units. They were very much larger than the German furnaces, and the design and construction was quite new. They functioned extremely well as such furnaces go, considering the complicated operation The time of an operation, including salt melting and reaction, was reduced to about 2½ hours, and the salt-melting furnaces were never used for their intended purpose.

Salt, charged cold, was first melted in the furnace by adding directly to the hot furnace, the heated walls conducting sufficient current to start the melting. Into this bath of molten salt cyanamid was fed by hand, stirring up the bath with an iron rod, and as soon as all the cyanamid was in, the furnace was tapped by pouring into chill cars. After cooling, the cake was broken up and loaded into caustic soda drums which formed the shipping container of the final product. Later it was tapped directly into the shipping drums.

The process was somewhat troublesome to carry out. The life of the low-grade magnesite brick lining, the only kind then obtainable, was at most six weeks. It then became so conducting, due to the iron content of the bricks being reduced by the cyanide and through its absorption of the cyanide itself, that relining was necessary. Further, the addition of the cyanamid had to be slow and cautious as considerable foaming took place during the reaction and the contents of the furnaces would frequently boil over. The first great improvement was the discovery that the addition of a very small amount of calcium carbide to the furnace would entirely stop the foaming. This permitted the cyanamid addition to be made very quickly and the power input was, therefore, increased to obtain the additional melting speed. I had learned in Germany that the furnace men over there were of the very fixed opinion that at no time should the temperature of the bath rise above 960° C., or decomposition of cyanide would result Due to an accident to the electrical system at Niagara, one of the furnaces received an undue amount of electrical power in one of the runs, and the temperature shot up several hundred degrees above the limit set by the Germans, yet most excellent results were obtained. All furnaces were, therefore, operated at the highest possible temperature, and as a result within three months of the starting of the plant the Cyanamid Co. not only maintained a daily production rate of nearly four tons of sodium cyanide but had carried on experimental work which had enabled it to dispense entirely with the salt melting furnace, as well as some of the reaction furnaces, to cut down the time of reaction to half, to avoid foaming, and further to increase the test of the finished material up to approximaely 24 per cent. equivalent sodium cyanide.

The unsatisfactory performance of hte tilting furnace led the Cyanamid Co. to experiment with a new type using a suspended electrode and the combination arc-resistance method of heating. The success following this development enabled it to abandon the numerous small resistance furnaces and concentrate its eorts in a single unit and at the same time to obtain a very greatly improved product. After a short period of development there was constructed at Niagara a singe-phase fornace with conducting hearth and containing a single suspended electrode and which furnace starting with an initial capacity of some 10 to 12 tons of product per day running about 28 per cent sodium cyanide equivalent, is now operating at nearly 30 tons of product per day, averaging 42 per cent equivalent sodium cyanide. Additional furnaces are in process of construction.

The development of the industry has been quite rapid. In 1917 there was produced approximately 2,187,000lb, equivalent to 100 per cent sodium cyanide. In 1918 this grew to 2,350,000. In 1919 a very considerable revision of the process and equipment was made, and as a consequence the plant operated only seven months, during which period it produced at the rate of over 4,000,000lb. of NaCN per year. aThe quality of the product started at about 14 per cent equivalent sodium cyanide in January , 1917, and in August, 1919, ran uniformly between 36 and 37 per cent equivalent sodium cyanide. Material running as high as 50 per cent equivalent sodium cyanide has been produced and there have been shipped several carloads running around 45 per cent, of which I shall speak more later.

The process and apparatus used for manufacturing this product has been extensively described in the many United States and foreign patents covering the process. Essentially cyanamid, salt and calcium carbide are mixed together and continuously fed to a single-phase furnace designed so that it has a very small cubical capacity as compared with the power input. Melting is extremely rapid and the fused product is removed from the furnace almost continuously to a cooling device which instantly chills the product. This is necessary to prevent reversion of the initial reaction, whereby calcium cyanamid, plus its contained carbon, is converted into cyanide. The proportions of cyanamid and salt vary with the product to be made.

In 1917 operations were started with two parts of salt to one part of lime nitrogen and gradually decreased in salt content until in making the present standard 42 per cent product more cyanamid than salt is being used. The large furnace has been successfully operated with proport ons as low as two parts of cyanamid to somewhat less than one part of salt, and the experimental furnace

The resulting product is marketed in the form of small, thin scales of a greyisn-black to shiny-black appearance, and the standard grade known as Aero Brand Cyanide "Grade X" contains between 36 and 37 per cent equivalent sodium cyanide. This method of expressing its composition is used because it is sold on the basis "per pound of sodium cyanide equivalent." A constitutional analysis of the material has so far proven impossible of execution, but evidence points to the fact that it consists of a mixture of calcium cyanide, sodium chloride, and free lime with fractions of a per cent each of calcium carbide, calcium cyanamid, and other minor impurities obtained from the ash of the coke used in cyanamid manufacture. The product known as Aero Brand Cyanide "Grade XX" contains 45 per cent equivalent sodium cyanide—the cyanogen being actually present as calcium cyanide—a slightly bigher percentage of free l me and a materially lower percentage of salt than the X grade.

As to the use of this material it has found an enthusiastic reception in the mining industry. Being made from cyanamid, one of the cheapest forms of comhined nitrogen, and common salt, its cost of manufacture and its selling price are materially less than the purer forms of cyanide hitherto on the market. The use of caustic soda drums for packing has cut down the expensive item of metal containers forced upon the early industry.

The first Aero Brand cyanide made in 1917 went into the precious metal industry after a short series of laboratory tests in which it was demonstrated that it would dissolve gold and silver with equal efficiency to the 98 per cent grade then in the market, and that the accumulation of soluble salts due to the cyclical use of solutions in tbe mill would not prove troublesome. In mill scale operations the drums were opened up and the cyanide placed in a revolving tumbler which dissolved it in water, thus giving an opportunity for any acetylene produced to be evolved outside of the mill solutions. Containing as it does a small amount of insoluble material, part of which is carbon, difficultly with precipitation due to the presence of this carbonaceous material was feared, and the solutions were therefore filtered before passing into the mill circuit. Experimental work quickly determined that the carbonaceous residue had no precipitation effect upon cyanide solutions of the precious metals and this early practice of pre-solution was quickly abandoned and from thence to the present time Aero Brand cyanide is dumped directly into the mill circuit.

The presence of a small amount of sulphur in the cyanamid is carried through into tbe Aero Brand cyanide as a sulphide. Difficulty was feared with the presence of this sulphide, but several years' experience has shown that the aeration as employed in the cyanide mills quickly oxidises these sulphur compounds and renders them harmless. As a result no trouble has been experienced from its sulphur content.

In the gold industry, where the cyanide consumption per ton of ore is comparatively small, no difficulty has ever been experienced with the accumulation of soluble salts. In the silver industry, where cyanide consumptions of not over five pounds equivalent potassium cyanide per ton of ore is experienced, they have similarly had no trouble from accumulation of the soluble salts, but where consumptions are considerably above that figure, certain difficulties have made themselves shown in several of the silver mills. The calcium chloride obtained from double decomposition of calcium cyanide and sodium chloride acts as a precipitating agent and greatly assists in the settling of the mill solutions. Its accumulation in such a solution, however, to an undue extent, particularly in the case where cyanide consumptions run from 10 to 100lb. per ton of ore or concentrates leads to a decrease in the available alkalinity of solutions, and steps have had to be taken to eliminate it. These steps consist in the addition of any simple precipitating agent for lime, the precipitated lime heing removed in the filter with the mill tailings.

In every case, either in the laboratory or in the mill, the cyanogen content of Aero Brand cyanide has proven itself equally as efficient in the extraction of precious metals as that of the 98 per cent sodium cyanide pound for pound of contained cyanogen, added to which are the advantages of a considerably lower cost, slight alkalinity of the Aero Brand cyanide, and the marked influence on the rate of settlement of the solution. The new product has found a most favourable reception in the industry and is very widely and extensively used to-day. In the gold mills it offers no problem in handling and causes no difference in the practice beyond the fact that the making up of a stock solution is not considered as good practice as the dumping of the cyanide directly into the barren solution along with the ore. In the silver mills, using a considerable quantity of cyanide per ton of ore, simple precipitating methods for eliminating accumulated lime are in use, otherwise their practice is in no way affected.

In its present state of development Aero Brand cyanide is not adapted to use in the case-hardening industry or in electro-plating. For the case-hardening industry is is very questionable if it has anything to offer in the future, but in the electro-plating indnstry steps are being taken to perfect a method to simply convert it into forms such as the electro-plater can conveniently use, and it will undoubtedly make some headway in that industry.

For the preparation of cyanides it is a simple matter to dissolve Aero Brand in water, adding sufficient soda ash to eliminate the lime and filter. It is then ready for precipitation of the various insoluble cyanides.

For the preparation of ferro-cyanide it is very satisfactory. A solution of ferrous sulphate is made up of suitable strength and into this is dumped an equivalent amount of Aero Brand cyanide and the mass agitated for a short time. Quantitative transformation of the cyanogen in Aero Brand to ferro-cyanide readily takes place. The insoluble material left in the treatment vat is filtered off, the filtering operation not being very complicated, but tbe amount of cake to be handled is considerable. The resulting ferro-cyanide is then concentrated and at a certain density about 95 per cent of it will separate out as a meal and the other 5 per cent will remain behind in solution with the chlorides of calcium and of sodium. The meal is separated in a salt filter attached to the evaporator and the solution is thrown away. Recrystallisation of the meal with return of mother liquor to the original treatment tank yields a

sodium ferro-cyanide of remarkable purity. The transformation can be accomplished with not over 5 per cent loss of cyanide.

Recently the manufacture of anhydrous prussic acid from the crude cyanide has been successfully undertaken. Into an acid-proof generator Aero Brand cyanide and water is charged, the apparatus closed up and sulphuric acid run in. A considerable evolution of prussic acid gas takes place and the solution in the generator is finally cleared of all prussic acid by the admission of live steam. A brine-cooled condenser liquefies the gas evolved from the still and condenses an impure acid containing about 80 per cent prussic acid. This is charged into an iron still and re-evaporated, the resulting condensate being about 98 per cent pure, in which state it is used in fumigating in the citrus growing districts. The resulting liquefied product is water white aod practically chemically pure, at most containing only the most minute traces of foreign products. The construction and operation of the liquid gas plant, as the same is called locally, has been a most successful operation in every way, the only regret being that the installation was not about three times as large as originally planned because of the great demand for the high quality material it has turned out.

There is no reason to doubt that Aero Brand cyanide will find a place in many other chemical industries as up to the present time practically no limitations in its use have been found and no chemical properties which prevent its utilisation in the many cyanide derivatives. Quite recent developments have shown the feasibility of manufacturing the higher-grade product containing above 45 per cent equivalent sodium cyanide. These developments are too new to present at this time. A discussion of the process or of the use of the resulting product, which has several new characteristics will be reserved for the future.

Conclusions.

The development of the process of transforming cyanamid into cyanide marks another triumph of the American electrochemist. We accomplished more in a few months than the foreign chemists accomplished in 15 years. Three months after starting the designs of a plant our American chemists were producing to the extent of four tons of equivalent sodium cyanide per day of a much higher grade than the Germans had ever hoped for. Within a year we had reduced our operation to a single small electric furnace of a continuous type and produced a product of higber cyanide content than the Germans ever thought possible and at a nitrogen efficiency of over 90 per cent.

The resulting product of uniform quality and excellent physical characteristics has found a very increasing market in the various industries using such a product and is to-day pushing the pure high-grade product steadily out of its long entrenched fields. For the present year the outlook is for a consumption of Aero Brand cyanide equivalent to nearly 5000 tons of 100 per cent sodium cyanide. With further development along the lines of transforming this material into its many other derivatives, particularly in view of the very low cost of the raw materials entering into its manufacture, and the simple apparatus and process used, we confidently look forward to cyanide made from cyanamid dominating the world's cyanide market.

VENTILATION AND HUMAN EFFICIENCY.*

(Concluded from page 310.)

In Scotland the majority of the lamps were the little miners' lamps for which Englishmen as a rule had a strong contempt, but, notwithstanding the contempt, he was glad to see that a patent lamp of the kind was coming into favour in England. Therefore, the English colliery manager had to thank the Scotch colliery manager at least for giving him that tip. The further they went into the works the more the air became contaminated, and the men at the end were undoubtedly swallowing very bad air. That was a matter which they could not possibly help, and the only cure for it was, as Dr. Haldane had said, by sending a large current of air to sweep through the colliery workings.

A good deal of discussion had been started, particularly in Scotch coal-fields, with regard to obtaining fresh air at the faces, and the question whether or not it could be done by the existing method of providing ventilation from the surface alone, by which he meant having a suface fan with a good-sized down cast shaft and a good-sized up cast shaft, or whether it was better to have auxiliary fans underground. Some managers declared that by having auxiliary fans, the air was cooled. He was not so sure about that, but some mangers held that the air that came from an auxiliary fan placed underground was much cooler than when the whole air came right in from the surface and went right back from the one fan. That was a question that Dr. Haldane might take up, if he had time, and settle the knotty point.

The paper he thought was of great value to mining engineers, and he only regretted that all members of the Institution of Mining Engineers did not have the opportunity or reading it. If some arrangement could be made whereby such papers read before the Institution of Mining and Metallurgy could also be discussed by the Institution of Mining Engineers, he thought it would help both Institutions and the Industry generally. He desired to thank the President and members for permitting him to contribute to the proceedings, and he had also to thank the author for his excellent paper, which he had thoroughly enjoyed.

Mr. Bernard W. Holman said that he was sure they were all very grateful, as mining engineers, to Dr. Hill for having brought that instrument before the Institution, and for having explained it so clearly. It now behoved the mining engineering profession to test it themselves and find out how far it could actually be employed usefully in the mines.

One of the first things that occurred to one was its use for testing the efficiency of booster fans underground. An instrument which actually gave the cooling power per unit of surface seemed peculiarly fitted for testing whether the increase of air velocity obtained by booster fans gave an increase of cooling power commensurate with the additional amount of money spent.

It was possible to test a man's efficiency by the

* Discussion before the Institution of Mining and Metallurgy,

katathermometer in conjunction with an ergometer which gave actual measurements of how much work the man put out. To begin with, as the Mine Rescue Apparatus Committee had shown very clearly in their report, the instrument not only showed what output the man was capable of, but it also showed his stamina (suitability for sustained effort), and his fitness. By finding out what his efficiency was they could find out how far his output could be improved. They all knew that in Africa and other places it had been necessary to employ new classes of natives and other workers underground. The only practical method of testing them was to measure their output and to see how much the death-rate turned out to be per thousand per year. Obviously sometimes such tests had to be stopped because the death-rate would be too high. Such a method was troublesome and expensive. Efficiency tests on individuals would be far more convenient and much cheaper. It could be tried in practice whether this method of testing the suitability of men for working underground gave reliable results.

Then there was a third use which remained to be tested by mining engineers, and that was the effect on output of the general conditions of the mines. The man's efficiency could be tested at different depths, temperatures, and humidities. There was also the peculiar question of optimum effort which Dr. Orenstein was going into so fully, i.e., whether it was better to let a man work very hard and then have a rest, or whether it was better to let him have one or two or three rests throughout the shift, and what was the best length of shift. That was a test for which the katathermometer happened to have a particularly useful scope. They had been so much in the dark before with regard to the influence of cooling effect on a man that a good deal had had to be held over.

With regard to the recommendation of the ergometer he felt that it was a matter of opinion rather than a statement of scientific fact that efficiency depended on cooling power; efficiency should be measured. They had heard he statement made that the cooling power was the measure of efficiency, and that the cooler the air was the higher the efficiency of the man. Any statement connected with human efficiency and the human machine ought to be treated really as an empirical one, because they knew very little even about the process of oxidation in the tissues. To quote a President at the last Meeting of the British Association: "We do not know how it is done, and we cannot do it ourselves." He (Mr. Holman) almost thought that applied to such a simple thing as digestion also. Therefore they had these factors: cooling power, comfort, and efficiency. They were three different things; although they were undoubtedly connected they were not necessarily equivalent. It was interesting to note the very elaborate experiments which had been carried out by the French Army recently to test new recruits joining the Army in order to see how far and with what loads they could march, and how on a forced march a rest of ten minutes per hour, or five minutes per hour, or no rest at all, affected the efficiency of the men. It seemed to him that in precisely the same way that instrument could be used to test the real capability of a new man presenting himself for work. When the fuel consumption side of the instrument was simplified slightly, presuming the man would submit to it and that his Union would let him, it seemed to him that it would be possible to test a man's actual physical efficiency for work before engaging him.

The effect of alcohol had been very carefully studied by means of the ergometer, also the amount of energy used, and the conditions of efficiency of workers in various industries, even including men hewing coal, had been already investigated by Prof. Waller.

It was very interesting to see the amount of modification in the revised formulæ of Dr. Hill. He (Mr. Holman) rather doubted their absolute validity when he saw them at the previous meeting because he had not been quite able to see how the cooling power varied with the root of the velocity. When they dealt with rather higher velocities for air-cooled engines for aeroplanes, the cooling power appeared to vary directly with the velocity. In the army they had to make allowance for shell-fuses burning more quickly when the shell was going through the air than when it was on the bench being tested. In that case there was actually a heating effect owing to increased velocity and not a cooling effect at all. He would like to ask Dr. Hill what absolute methods of checking low velocity he had, and whether he used any kind of hot wire anemometer, e.g., that of Dr. Vessot King, or whether he put a given quantity of heat into the wind tunnels and calculated in that way. For high velocities pressure measurements were sufficient.

There was one point on p. 2 with regard to the organic poisons in the exhaled air and the supposition of the existence of such being negatived by exact experiment. They all knew how continued insanitary conditions appeared to breed fever in the past. He would be very much obliged for references to any experiments on human beings in that connection. They all knew about the experiments on guinea pigs, which could almost live without any ventilation at all, and even live with carbon monoxide for quite a long time. He would be very glad of any references to prolonged experiments on men which dispelled that ancient "superstition" about exhaled air.

With regard to Dr. Hill's statement on p. 2 that high cooling power improved the circulation of blood and caused "better appetite, digestion and absorption of food and that constipation is avoided," he (Mr. Holman) thought that all those things were very often constitutional. From his own experience and observation appetite was quite a constitutional thing, and often independent of body weight. He thought, therefore, that such things being largely constitutional varied far more with the individual than they did with katathermometer readings.

Mr. H. K. SCOTT said that Dr. Haldane, in determining the measure of atmospheric conditions suitable for the efficiency of workers, had stated that at 80° F. wet-bulb, the work of a miner falls off, and at 85° F. hard work is scarcely possible.

At the Morro Velho Mine of the St. John del Rey Mining Co., in Brazil, however, the temperature in the stopes on more than one occasion last year actually reached 90° F. wet-bulb, and unless

some method had been evolved of reducing this figure, further excavation in depth would have been impossible. As a result of the installation of a cooling plant, which has been in operation there since last December, the temperature fell appreciably, and three months later, the thermometer nowhere registered more than 83° F. wet-bulb in the mine.

The cooling plant has been worked to bring about a very gradual fall in temperature, in order to prevent blistering of the rock, but Mr. Scott was informed that at the present time men were working underground wih their coats on. This appeared to him a very satisfactory result, inasmuch as the improved conditions would prolong the life of the mine, as well as reduce sickness and tend to prevent industrial unrest.

This result has not been achieved without large expenditure, which, he understood, approached two hundred thousand pounds This figure, however, included the provision of power, in addition to that of the cooling plant proper. The incidence of the War, and the fact tbat the installation was a pioneer one, no doubt resulted in the expenditure being so great.

The author suggested that by adjusting the cooling power to the heat production of the worker, sweating could be prevented, and the work done with comfort and ease.

He (Mr. Scott) would ask Dr. Hill if, in his reseaches, he had taken into consideration the fact that men do not all sweat at the same temperature and with the same physical exertion. He presumed that an average figure had been taken which would probably give a satisfactory result in factories, but he was afraid tbat, although in deep mines improved ventilation make work more tolerable, the environment would not permit such ideal conditions as the author postulated.

The President said that he felt sure that the members would all join with him in passing a hearty vote of thanks to Dr. Hill for his very interesting paper, a paper which, although a theoretical one, was of great interest to practical men because it was through scientific men bringing these things forward that practical men were enabled to adapt them to their particular conditions and make them of practical use.

Contributed Remarks.

Mr. H. F. Collins: It seems to me that the katathermometer is nothing but an improved form of wet-bulb thermometer *plus* a time factor; what it measures is simply the evaporative power of a current of air. If this be so, the same result ought to be measurable by noting the difference between the dry and wet bulb temperatures, and the time taken by the wet bulb to reach this difference, which ought to be standard for each given set of conditions. A factor can then be worked out for converting the readings of any wet-bulb thermometer into kata degrees.

There are cases in which the indications of a katathermometer, graduated only from 100° down to 95°, would be of no value, for one often finds—especially in tropical countries—working places the temperature of which is above 100° F. On two occasions in the writer's life it has been his lot to visit working places the temperature of which (from special causes in each case) exceeded 130° F. For such conditions the kata would be useless, whereas our old friend the wet-bulb, the readings of which had been standardised against a kata, could be employed successfully.

PROCEEDINGS OF SOCIETIES.

ROYAL SOCIETY.

November 24, 1921.

Prof. C. S. Sherrington, President, in the Chair.

The following papers were read:—

(1) *"Observations on Reflex Responses to the Rhythmical Stimulation in the Frog."* (2) *"The Effects of Constant Galvanic Currents upon the Mammalian Nerve-muscle and Reflex Preparations."* By K. Sassa.

(1) The object of the investigation was the study of the relation between the frequency and intensity of stimulation and the resulting reflex reactions.

It was found that there is an optimal intensity when the rate of stimulation is rapid, but not at moderate rates. There is also an optimal rate for any given intensity. The reflex contraction evoked at optimal rate of excitation is often nearly as powerful as tbe direct one obtained by similar stimulation, especially in the first period of contraction.

(2) This communication gives the results of a study of the reflex effects resulting from stimulation by constant galvanic currents applied to an afferent nerve of the hind limb.

The main points of enquiry have been: (1) the relation between reflex excitation and inhibition of the decerebrate tonus of the vasto-crureus; (2) whether the "excitation formula" (Pflüger's law) holds good in mammalian afferent nerves; and (3) whether there is continuous excitation during the passage of the current through an afferent nerve.

"The Hæmolytic Action of Sodium Glycochocolate." By E. Ponder.

In this paper it is pointed out that the hæmolytic power of sodium glycochocolate is greatly increased by the addition of small amounts or histamine or histidine.

The effect produced by such a mixture on freshly prepared erythrocyte suspensions differs from the effecr produced on supensions which have been standing for some time. Erythrocytes can be rendered immune to the hæmolysis produced by mixtures of sodium glycochocolate and histamine by the previous addition of histamine to the suspension.

It is suggested that the hæmolysis is due to changes of surface tension.

Tables illustrating the phenomena are given.

"The Titration Curve of Gelatine." By Dorothy J. Lloyd and C. Mayes.

Hydrochloric acid combines with gelatine in solutions whose acid concentrations are less than 0·04 normal, according to the law of mass action. K_b for gelatine is $4{\cdot}8 \times 10^{-13}$ if 839 be taken as the reacting weight of gelatine.

The theory is put forward that over this range of the curve of combination of gelatine with

hydrochloric acid, the combination occurs at the free—NH_2 groups. These groups are present in the lysin, arginin, and possibly some other of the amino-acids of the gelatine.

In dilute sodium hydroxide of a concentration less than 0·01 normal, the gelatine combines with the base less rapidly than would follow by a calculation from the value for K_b and the value for the iso-electric point, if 839 is taken as the reacting weight.

It is suggested that the number of positions of attachment for bases is not the same as the number of positions for acids, *i.e.*, that the reacting weight $= \frac{\text{molecular weight}}{\text{basicity (or acidity}}$ is not the same in acid and alkaline solution.

"Idio-Ventricular Periodicity." By D. H. DE SOUZA and J. A. HEWITT.

A perfusion experiment on the excised heart of a frog is described and discussed, in which periodic grouping occurred as an independent ventricular phenomenon.

SOCIETY OF PUBLIC ANALYSTS.

Ordinary Meeting, December 7, 1921.

Mr. ALFRED SMETHAM, President, in the Chair.

CERTIFICATES were read for the first time in favour of Messrs. John Leonard Lizius, B.Sc., A.I.C., Harry Malkin Mason, M.Sc. (Sheffield), F.I.C., Thomas McLachlan, A.I.C., Charles March Caines, F.I.C., and Girija Nath Mukerjee, B.Sc. (Cal.).

Certificates were read for the second time in favour of Messrs. Jack Cecil Drummond, D.Sc. (Lond.), F.I.C., Alfred William Long, John Charles Mellersh, Charles Harold Wright, M.A. (Cantab.), F.I.C.

The following papers were read :—

"The Estimation of Small Quantities of Antimony in Copper and Brass." By B. S. EVANS, M.B.E., M.C., B.Sc., F.I.C.

The author states that existing methods are unsatisfactory, either on the score of length or accuracy, and puts forward a process which he claims to be reasonably rapid and accurate. The method is described in detail, the copper being first eliminated with sodium hypophosphite and the antimony precipitated on copper foil, from which it is dissolved and re-precipitated as the sulphide, and estimated colorimetrically. The chemistry of the process is dealt with, and the factors governing the Reinsch and hypophosphite tests for arsenic discussed.

"The Inks of Ancient and Modern Egypt." By A. LUCAS, O.B.E., F.I.C.

The author refers to the types of pens used in ancient Egypt and gives an account of the black and coloured inks on ancient papyri and parchments. The chemical reactions of these inks are described, and an analysis is given of a carbon ink of the sixteenth century, B.C. The inks in old Arabic and Coptic books are next described, and evidence of the use of iron inks in papyrus MS. of the seventh century A.D. is adduced. The composition and characteristics of modern Egyptian inks are outlined and analyses of different qualities of carbon inks are given. Finally the question of the brown discolouration of ancient carbon inks in MS. and books is discussed and explained.

"Notes on the Analysis and Use of Red Squill in Rat Poisons." By C. L. CLAREMONT, B.Sc., F.I.C.

Red squill (*Urginea Maritama*) is described, a short *resume* of previous work given, and methods of using as a raticide explained.

The author gives analyses and toxic values of a number of red squill powders, the main feature of which is the presence of a sugar-like substance which serves as an indication of the presence of squill, and gives approximate quanti-relationship results, but it does not appear that there is any relationship between this and the toxic value. Similar figures derived from the white squill (B.P.) and *Urginea Burkei* are also given and the difficulty of distinguishing red from white squill dealt with. Analyses of liquid extracts of a squill and other rat poisons containing squill are given, and experiments are described bearing on the best method of making squill preparations.

NOTICES OF BOOKS.

Aids to Chemistry. By WILLIAM PARTRIDGE, F.I.C. Pp. viii.+280. London: Baillie, Tindale & Cox. Price 6s. net.

This little book is intended for the use of students who have already been through a course of chemistry, and have therefore had some experience in practical work. The object of the text has been to recall and explain to the reader the various reactions he has encountered in his laboratory work, and to act as a handy book of reference.

After an introduction dealing in a general way with the science of chemistry, and the indestructibility of matter, short paragraphs are devoted to compounds and mixtures, synthesis, and analysis.

A chapter is given to optical chemistry and the use of the spectroscope, and then the subject of the non-metallic elements, their occurrence, history, and reactions, occupy some 50 pages, while the remainder of the book deals very practically with the quantitative analysis of compounds and the chemical nature of the hydrocarbons.

Naturally, when embracing such a range of subjects in a small book, the matter is very condensed, but as an aid in recalling the mind to work that has been done in the laboratory the book will no doubt be found of value to medical, veterinary, and pharmaceutical students. A list of the elements with their symbols and approximate atomic weights is given at the end of the book, and there is a general index.

A Handbook of Laboratory Glass-Blowing. By BERNARD D. BOLAS. Pp. vi.+104. London: George Routledge & Sons, Ltd. New York: E. P. Dutton & Co. Price 3s. 6d. net.

This handy and clearly illustrated booklet is devoted to the subject of such glass-blowing as is generally encountered in laboratory practice. It is quite evident by the descriptions and illustra-

tions given that the author is writing from a very practical point of view. By closely following the directions and the use of a plentiful amount of patience, it should be quite possible for the student with average manipulative skill to become sufficiently proficient to enable him to manufacture for himself nearly everything that is needed in the laboratory.

In addition to glass-blowing, many dodges useful in the laboratory are given, such as drilling and grinding glass, calibration and graduation of glass apparatus, manufacture of thermometers, spinning glass, and the making of Sprengel air pumps, and illustrations are given of the method of making the extremely complicated Geissler tubes that were to be seen in every optician's shop years ago.

This is a book that we should strongly recommend to all workers in science, especially chemical students.

An Introduction to Zoology for Medical Students. By C. H. O'Donoghue, D.Sc., F.Z.S. Pp. x.+501. Price 16s. net.

The object of this imposing volume is to provide a textbook for the zoological portion of the syllabus in biology for the first examination for medical degrees in the University of London.

An introductory outline is given to the probable theories relating to heredity and evolution, and it is pointed out that no course in zoology can be considered adequate unless the reading is accompanied by practical work. No pains have been spared to fully illustrate the work by both half-tone plates and diagrams.

We are rather surprised that little or no reference has been made to the application of X-rays for the investigation of osteological structure. It was thought in the early days of Roentgen's discovery that the method would be found of value. It may be that the science of radiology has developed in a direction that makes it difficult for the zoological student to avail himself of this valuable means of research.

The Spectroscopy of the Extreme Ultra-Violet. By Theodore Layman, Ph.D. Pp. 132 London: Longmans, Green & Co Price 5s. net.

This work is one of the series of monographs on physics, edited by Sir J. J. Thomson, O.M., F.R.S., and Frank Horton, D.Sc., M.A. The author in his preface states that the book might well have been called the Spectroscopy of the Schumann region. The work of the late Victor Schumann will always be remembered by spectroscopists in connection with the exploration of the spectrum in the extreme ultra-violet. The excessive care which he took in every detail in the construction of apparatus and the magnificent results that he obtained really laid the foundation for the research in this important field. Professor Layman's work on the subject is well-known.

Part I. deals with the photometry of ultra-violet and the absorption of solids and gases. Chapter II. begins with the description of the apparatus used in the investigation of the ultra-violet. This portion is very clearly illustrated, and diagrams of the vacuum spectrograph are given. On page 54 a description is given of Schumann's photographic plate, having the remarkable property of being very sensitive to the extreme ultra-violet, but quite insensitive to light of greater wave-length than A.U. 3000; the shortest wave-length obtained by the direct method appears to be in the neighbourhood of 900 A.U.

As it has now been established that X-rays are a form of ether vibration of wave-lengths in the neighbourhood of one and two Angstrom units, the gap between the X-rays and the shortest ultra-violet radiations is still of absorbing interest, and the author thinks that it will probably necessitate a considerable change in the methods of investigation if the gap is to be successfully bridged. Work in this direction is stated to have been carried out by Dember, who produced X-rays by the bombardment of photo-electrons of low speed of an estimated wave-length of 475 A.U.

Tables of wave-lengths in the ultra-violet spectrum, of hydrogen, nitrogen, argon, aluminium, gold, and some other elements are given, and in an appendix at the end, Schumann's method of preparing the photographic plate and the developer is described.

The Formation of Colloids. By The. Svedberg, Professor of Physical Chemistry in the University of Upsala. Pp. 125, with 22 Illustrations. London: J. & A. Churchill. Price 7s net.

Professor Svedberg's name is well-known in connection with the subject of colloids, and it is with very great pleasure that we are able to announce that he has undertaken the publication of a series of monographs upon the subject. It is proposed by this method to keep up to date with this rapidly growing science. Professor Svedberg, in his preface, refers to the help he has received from Emil Hatscheck, whose name is also well-known in this connection.

The first of the series now before us gives a survey of the processes which cause the formation of colloids. In his introduction, the author gives full credit to the labours of Thomas Graham, whose experimental investigations laid the foundation of the science of colloidal substances. Since those days, many investigators have devoted themselves to researches in this fascinating field. The names of Linder, Picton, Zsigmondy, and Ostwald, will always be associated with the pioneer work that has been done on the subject Ostwald has referred to the colloids as "the world of neglected dimensions" because of the lack of interest which, until very lately, caused them to be a disregarded field of study.

The first paper in the monograph is devoted to the formation of dispersed systems in vacuo, and deals with the metallic deposits on glass and other surfaces. There is a critical temperature for every element, above which the molecule instead of adhering to is reflected from the surface. This temperature for mercury is about minus 135° C., and for silver plus 575° C.

The formation of mercury mirrors upon cooling a globe containing mercury vapour is familiar to all frequenters of the Royal Institution of London by the classical experiments of Sir James Dewar. The practical application of the knowledge of these phenomena is well brought out in the concluding paragraph of this paper, where it states that if the glass upon which the condensation is to take place is covered beforehand with a thin film of some salt, no coherent

metal film is formed. This knowledge has already been applied by the makers of metal filament electric lamps to prevent the darkening that takes place by use, and it is stated that the insides of the glass globes have already been coated with very thin films of certain salts, and that the results have been very good indeed.

The formation of colloids by the electric pulverisation of metals is exhaustively discussed and a great number of illustrations of apparatus and particulars are given. At the end of this portion of the book is a very complete bibliography of work that has been done on the subject.

The latter part of the book is devoted to a treatise upon the formation of dispersed systems in liquids and in solids This chapter is full of the most interesting material. Chemical reactions, gold sols, Faraday's experiments, silver sols, silver mirrors, experiments of early investigators, the preparation of ruby glass, and kindred subjects are touched upon, ending with bibliography. The book concludes with a name and subject matter index.

We shall look forward with very great interest to the succeeding numbers of this valuable series of monographs.

Priestley in America, 1794—1804. By EDGAR F. SMITH, University of Pennsylvania. Philadelphia: P. Blakiston's Son & Co. Price $1.50.

The author has collected together a fund of interesting notes connected with the emigration of Priestley to America, his reception in that country, and the work he did during the period between 1794 and 1804. The value of the presence of Priestley seems to have been very fully recognised by the chemists of that country and his teaching had undoubtedly a great effect on the development of chemistry in the young Republic. The author has collected a great deal of matter from contemporary newspapers, documents, and books, and has endeavoured to weave the whole into a connected sketch. A great number of Priestley's original letters are reproduced, which are of deep interest not only to the American reader, but to chemists in general.

Priestley's fame as a chemist and also as a preacher appears to have been very greatly appreciated at the time. Some of the newspaper clippings show what that strange power, the newspaper world in those early days, thought of the Rev. Dr. Joseph Priestley. An account was given of a meeting at Columbian Tavern on March 27, 1797, in commemoration of his birth, where it is recorded that a number of toasts were given, from which we reproduce the following:

"That illustrious Christian philosopher, Joseph Priestley. May the world be grateful to him for his services, as his services are beneficial to the world."

"Truth—may the splendour of her charms dissipate the gloom of superstition and expel hypocrisy from the heart of man."

"White-robed Charity—may she accompany us in all our steps and cover us with a mantle of love."

The writer concludes that it was "a feast of reason. The purest philanthropy dignified the conversation, and moderation and temperance bounded every effusion of the heart."

Although strong appeals were made by Priestley's friends that he should return to England, he determined to remain in the land of his exile. He continued working to the end, and it is reported that he was in the very act of correcting the proofs of one of his papers when he died on February 6, 1804.

Those who realise the work that Priestley did in those early days of chemistry will undoubtedly take pleasure in the many instances recorded of the whole-hearted and simple manner in which he worked.

Philosophy and the New Physics: An Essay on the Relativity Theory and the Theory of Quanta. By LOUIS ROUGIER. Authorised translation from the author's corrected text of "La materialisation de l'Energie," by MORTON MASIUS, M.A., Ph.D. Philadelphia: P. Blakiston's Son & Co. Price $1.75.

The author in his preface suggests that physicists as a rule are occupied too much with their special field to give much attention to matters of more general philosophical interest, and few philosophers possess the knowledge of science required for discussing and criticising fruitfully the work of the physicist, and he states that the book marks a measurable advance toward a confluence of the broad streams of philosophical and scientific enquiry.

The first chapter is devoted to the dualism of matter and energy, and after a brief introduction deals with the difficulties of the dualistic theory and concludes with a chapter on the inefficiency of Ostwald's energetice and the experimental discovery of the inertia of energy. Some chapters are devoted to electro-magnetic dynamics and the weight and structure of energy, and the author discourses on the dematerialisation of matter and the materialisation of energy.

In a chapter on radio-activity and atomic degradation of the elements, there is an interesting account of the discovery of radio-activity that is of very great value on account of the brevity and great accuracy with which it is given.

It is stated that the glass walls of a Crookes' tube were found to emit X-rays, and soon after this discovery M. Poincare suggested that inasmuch as the phenomena of emission and phosphorescence are inter-related, a phosphorescent substance should emit X-rays. This led to the discovery by M. Becquerel of the radio-activity of the salts of uranium and finally to the discovery by Madame Curie of the elementary substance radium.

The book, although small, is of very considerable interest at the present time, and the bibliography at the end adds much to its usefulness.

Introduction to General Chemistry: An Exposition of the Principles of Modern Chemistry. By H. COPAUX. Translated by HENRY LEFFMANN, A.M., M.D. With 30 illustrations. Philadelphia: P. Blakiston's Son & Co. Price $2.

The translator has done a real service to chemists by producing Prof. Copaux's work in English, and its value is greatly enhanced by the fact that Prof. Copaux was in touch with the translator while the work was in progress and suggested some changes in phraseology that add

to the lucidity of the text.

The book opens with an introduction giving the idea of the elements and the law of the conservation of matter. The atomic theory, chemical formulæ, inter-relation of the elements, properties and theories of solutions in chemical affinity are dealt with. A very good chapter is devoted to the atomic weights of the radio-active elements and Moseley's table of atomic numbers is discussed.

A large number of diagrams are given and an appendix at the end of the book deals with the structure of crystals and a contribution by the translator on hydrogen ion concentration.

CORRESPONDENCE.

BLINDED SOLDIERS' & SAILORS' HOSTEL.

To the Editor of the Chemical News.

SIR,—At this moment of my own and my mother's deep personal loss, I feel sure that I am voicing what would have been my father's wishes in asking that the public who have so fully and generously supported his unceasing work for St. Dunstan's and the National Institute for the Blind, should continue to help that work in every possible way.

My father's deepest concern was that the public should regard his work for the blind not merely as a personal effort of his own, but as a National Trusteeship placed in his hands by the people of the Empire.

I ask, therefore, in his name, that all present and projected activities to raise the much-needed funds for the work to which my father devoted his life should continue without ceasing for a moment. I am sure that he would have wished this.—I am, &c.,

NEVILLE A. PEARSON.

Headquarters of St. Dunstan's Work,
Inner Circle, Regent's Park, N.W.1.

ENGLISH IN LATVIA.

To the Editor of the Chemical News.

SIR,—The British public will be interested to hear that Latvia, one of the new Baltic States, has decided to make English the first foreign language to be taught in its University and schools. English and English ideals will, therefore, henceforth take a very important place in the education of this new State, with which our country has very close and other relations.

But the teaching of English is sadly hindered by the dearth of good books in our language, and the purchase of these at the present time by the Letts is impossible owing to the very adverse rate of exchange. The want which this condition of things reveals is one, however, which could easily be supplied, at very little cost to itself, by the British public, which now has a great opportunity to befriend a nation which has suffered much through the war and which earnestly desires to draw closer the ties of its friendship with Great Britain. There must be scores, nay hundreds, of thousands of books—standard works in our language, disused school books, useful in the teaching of English, as also scientific, engineering, and other professional works—for which their owners no longer have any use. It is for gifts of such books, as well as any others which can be spared, that I now appeal.

My appeal has the support of the following: Prof. Gilbert Murray, Sir Richard Gregory, Brig.-General A. Burt (late British Military Commissioner to the Baltic States), Mr. G. S. Tallents, C.B. (late British Commissioner in Latvia), Dr. Hagberg Wright (Hon. Secretary, Friends of Latvia), Mr. J. F. Green, M.P., and Mr. H. C. Woolmer. At their invitation Sir Alfred Davies, who so successfully organised the supply of educational books to our British and Colonial prisoners during the war, has kindly consented to direct the arrangements for book collections, and his former coadjutor, Mr. H. W. Atkinson, M.B.E., will give his services as Hon. Librarian.

May I, therefore, ask all who can spare, from their shelves, English books will, without delay, forward them to Sir Alfred T. Davies, K.B.E., C.B., c/o The Consul-General for Latvia, 329, High Holborn, London, W.C.1. I should like to be in a position, on behalf of the citizens of this country, to make a New Year gift to Latvia of at least 50,000 volumes.—I am, &c.,

JOHN BADDELEY,
Lord Mayor of London.

Mansion House,
December 3, 1921.

BOOKS RECEIVED.

"Laboratory Exercises in Applied Chemistry for Students in Technical Schools and Universities." By Dr. WILHELM MOLDENHAUER. Authorised translation by LAWRENCE BRADSHAW, D.Sc., Ph.D. Pp. vi.+236, with 36 Illustrations. 1921. London: Constable & Co. Price 12s. 6d.

"Elementary Chemical Microscopy." By EMILE MONNIN CHAMOT, B.S., Ph.D. Second Edition, partly rewritten and enlarged. Pp. xv.+476. New York: John Wiley & Sons Price 25s.

"Rays of Positive Electricity and their Application to Chemical Analysis." By SIR J. J. THOMSON, O.M., F.R.S. Second Edition, with Illustrations. Pp. x.+237. London: Longmans, Green & Co. Price 16s.

"Chemical Reactions and their Equations: A Guide and Reference Book for Students of Chemistry." By INGO W. D. HACKH, Ph.C., A.B. Pp. viii.+138. Philadelphia: P. Blakiston's Son & Co. Price $1.75.

"The Manufacture and Uses of Explosives." By R. C. FARMER, with Foreword by SIR ROBERT ROBERTSON, K.B.E., F.R.S. Pp. viii.+116. London: Sir Isaac Pitman & Sons, Ltd. Price 2s. 6d.

"Oils, Fats, and Fuels." By THOMAS HULL. Pp. viii.+143. 1921. London: Blackie & Sons; Glasgow and Bombay. Price 3s. 6d.

"Introduction to General Chemistry: An Exposition of the Principles of Modern Chemistry." By H. COPAUX. Translated by HENRY

LEFFMANN, M.A., M.D. Pp. x.+195, with 30 illustrations. Philadelphia: P. Blakiston's Son & Co. Price $2.

"Philosophy and the New Physics: an Essay on Relativity and the Theory of Quanta." By LOUIS ROUGIER. Authorised translation by MORTON MASIUS, M.A., Ph.D. Pp. xv.+159. Philadelphia: P. Blackiston's Son & Co. Price $1.75.

"Priestley in America, 1794—1804." By EDGAR F. SMITH. Pp. 173. Philadelphia: P. Blakiston's Son & Co. Price $1.50.

"Fuel and Lubricating Oils for Diesel Engines." By W. SCHENKER. Pp. xii.+112. London: Constable & Co. Price 10s. net.

"*Year-Book of Pharmacy—comprising* Abstracts of Papers relating to Pharmacy, Materia Medica, and Chemistry." With Translations of the British Pharmaceutical Conference. Pp. 418. London: J. & A. Churchill.

"A Text-book of Inorganic Chemistry." By A. F. HOLLEMAN, Ph.D., F.R.A. (Amst.). Issued in English in co-operation witb HERMON CHARLES COOPER. Sixth English Edition, revised. Pp. viii+527. London: Chapman Chapman & Hall, Ltd. New York: John Wiley & Sons. Price 9s.

"The Emission of Electricity from Hot Bodies." By O. W. RICHARDSON, F.R.S. Second Edition. Pp. viii.+320. London: Longmans, Green & Co. Price 16s.

NOTES.

THE Library of the Chemical Society will be closed for the Christmas holidays at 1 p.m. on Friday, December 23, and will reopen at 10 a.m. on Thursday, December 29.

ROYAL INSTITUTION.—The following are the lecture arrangements at the Royal Institution before Easter. Prof. J. A. Fleming—six lectures adapted to a juvenile auditory on "Electric Waves and Wireless Telephony," beginning on Thursday, December 29, on "Surface Waves on Liquids," followed by "Waves in Air," "The Telephone," "Electric Oscillations," "Electric Waves," and "Wireless Telephony." On Tuesday afternoons, commencing on January 17, there will be two lectures on "Physiology as Applied to Agriculture" by Dr. F. H. A. Marshall, three by Prof. H. H. Turner on "Variable Stars," five by Sir Arthur Keith on "Anthropological Problems of the British Empire," Series I., Racial Problems in Asia and Australasia," and two by Dr. J. W. Evans on "Earth Movements." On Thursday afternoons Mr. Seton Gordon will give two lectures on "Mountain Birds of Scotland and Sea Birds and Seals," Sir Napier Shaw two on "Droughts and Floods," Prof. A. G. Perkin two on "Dyeing: Ancient and Modern," Prof. H. Maxwell Lefroy two on the "Menace of the Insect Pest: The Balance of Life in Relation to Insect Pest Control," Dr. P. Chalmers Mitchell two on "The Cinema as a Zoological Method," and Prof. A. Hind two on "Landscape Etchers: New and Old." On Saturdays there will be two lectures by Dr. L. de Selincourt on "Humourists of the Seventeenth Century," (1) "Sir Thomas Browne," (2) "Thomas Fuller"; two by Prof. E. A. Gardner on "Masterpieces of Greek Sculpture," and six by Sir Ernest Rutherford on "Radioactivity." The first Friday Evening Discourse will be given on January 20 by Sir James Dewar on "Soap Films and Molecular Forces." Succeeding Discourses will probably be given by Viscount Burnham, Sir Francis Younghusband, Prof. D. Halliburton, Dr. R. S. Watson, Prof. J. Joly, Dr. C. M. Wenyon, Prof. T. R. Merton, Dr. A. P. Laurie, Prof. F. G. Donnan, Mr. A. B. Walkley, Sir Ernest Rutherford, and other gentlemen.

MANCHESTER LITERARY AND PHILOSOPHICAL SOCIETY (Chemical Section).—Dr. H. F. Coward, F.I.C., has been elected Chairman of the Section for the Session 1921-22. At the meeting of the Society held on Tuesday, November 29, Prof. Horace Lamb, M.A., Sc.D., F.R.S., Sir Ernest Rutherford, M.A., DSc., F.R.S., Sir Arthur Schuster, Ph.D., Sc.D., F.R.S., F.R.A.S., and Prof. G. Elliott Smith, M.A., M.D., F.R.S., were elected Honorary Members.

THE *Journal of the Society of Leather Trades Chemists* for November, 1921, contains an interesting paper upon the action of formaldehyde upon gelatin. The fact that gelatin is rendered insoluble by formaldehyde is considered to have been first brought into prominence by Ernest O. Beckmann in 1894. The paper contains a deal of interesting information, and the interest in this reaction for those engaged in leather technology is dealt upon. Formalin-gelatin is practically insoluble in cold water, and only slightly soluble in hot water. A long-continued heating in water results in the complete expulsion of formaldehyde and reversion to gelatin of the ordinary type. The elasticity of a gelatin-gel decreases enormously as it absorbs formaldehyde. The product has almost the brittleness of glass, and when broken it shows a conchoidal fracture. Sudden heating causes it to crack like glass under analogous conditions. This seems to point to a condition of strain and it led to an optical examination. The result was negative, and the conclusion was that formalin-gel is not under any physical strain corresponding to such strain as exists in glass.

DENMARK.—The Danish State Railways invite tenders for the supply of various pigments, soaps, and heavy chemicals. The specification enumerates the following articles (the tons are metric tons): 2 tons of dry lead white in lumps, 4 tons red lead, 1½ tons of zinc white, 3 tons of lamp black, 1½ tons of chestnut brown, 1 ton of light umber, 1·6 tons French yellow ochre, 80 tons crystal soda, 10 tons of extra fine whiting, 2 tons polishing powder, 47 tons of soft green or brown soap, and 3 smaller items of soaps, 2·2 tons of denatured spirits of wine for varnish and polish manufacture, 4 tons of turpentine oil (either French or mineral), 550 kgs. of nitric acid, 32 tons of 27 per cent sulphuric acid for use in accumulators, and 2½ tons of ammonia (S.G. ·963-·955). Tenders are to be in the hands of the "Maskinafdelingens Kontor," Trommesalen 5, 3rd Floor, Copenhagen, B., by 1 p.m. on Dec. 29. A copy of the specification and conditions of tender forwarded by the Commercial Secretary to H.M. Legation in Copenhagen (in Danish) can be seen by United Kingdom firms interested on application to the Department of Overseas Trade (Room 84), 35, Old Queen Street, Westminster,

S.W.1. A copy is also available for firms in the provinces unable to arrange for its inspection in London.

CONGO.—Notwithstanding the commercial depression in the Congo, satisfactory business is being obtained by some travellers to that country, and if the traveller is unsuccessful the reason is often to be found in his own unsuitability for dealing in that market. Such is the conclusion to be drawn from a dispatch on this subject from the Acting British Consul at Boma, who finds it necessary to remind United Kingdom firms of the *difficulties to be encountered by their travellers* if the latter speak the English language only, or are not fully prepared to quote prices French is essential, and Portuguese desirable. The Consul is prepared to give advice and full information concerning the merchants in his district to United Kingdom commercial travellers who, he hopes, will not fail to call at the Consulate and make use of the assistance he can give.

THE "ABDULLA" 1922 ALMANACK.—An "Abdulla" Almanack for 1922 has been published by the Bond St. cigarette specialists of that name. In accordance with the usual annual practice of the firm, *10,000 copies are offered for sale*, at the price of 1s. 6d. for the benefit of the British Red Cross Society, Abdulla & Co. bearing the expenses of production. As the Almanack contains twelve coloured illustrations, each specially drawn for the publication by a leading artist, there should be no difficulty in selling all the copies, *and the maximum benefit to the Red Cross Society* should be assured. We have seen a copy of this Almanck. *Apart from its philanthropic purpose* which is greatly to be commended, it is a splendid production far beyond the usual illustrated almanack, and Messrs. Abdulla are not only doing patriotic service in helping the Red Cross Society, but have given us something that will be a pleasure to see during the coming year. The printing is by the Spencer Press, Ltd, who are to be congratulated upon the work.

New Patents.

THIS List is specially compiled for the *Chemical News* by Messrs Rayner & Co, Registered Patent Agents, of 5, *Chancery Lane*, London, W.C.2., from whom all information relating to Patents, Trade Marks and Designs can be obtained gratuitously.

Latest Patent Applications.

31055—Dutt, E. E.—Process for manufacture and extraction of titanium dioxide and vanadiumoxide from bauxite ores. November 21

31085—Meter, J.—Method for diffusing and disseminating poisonous gases. November 21

31087—Moritz, R.—Stirring-device for mechanically-operated sulphate furnaces. November 22

31241—Moritz, R.—Apparatus for measuring acids, etc. November 22

31276—Roka, K.—Chlorination of methane. November 22

Specifications published this Week.

147118—Grunstein, N.—Manufacture of butyric aldehyde and butyl alcohol from crotonic aldehyde

149662—Verine Chemischer Fabriken in Mannheim,—Manufacture of sulphur dioxide by heating sulphates of alkaline earths, magnesium, *and iron*

171149—Mooney, F. M.—Manufacture of a solution of chromic sulphate

171281—Howards & Sons.—Manufacture of calcium magnesium and lithium acetylsalicylates

71292—Fohnson, J. Y.—Manufacture and production of anthraquinone derivatives

Abstract Published this Week

Dyes, Lakes.—Patent No. 170155—A new compound and process for obtaining Monoazo dyes, has been invented and Patened by F. Bayer & Co., of Leverkusen, near Cologne, Germany. Soluble *chromium compounds of the monoazo dyes from diazotized* anthranilic acid or its derivatives not containing hydroxyl groups and B-napthylamine sulphonic acids, or of those from diazotized anthranilic sulphonic acids and B-napththylamine, are obtained by boiling the dyes with chromium compounds. In an example, *diazotized anthranilic acid is coupled with 2-napthlamine-7-sulphonic* acid, the dyestuff salted out, boiled with chromium fluoride and water, and the chromium compound salted out; the anthranilic acid may be replaced by its chlor—and nitro-derivartives such as C_6H_3 (COOH) : $(NH)_2$: C1=1 : 2 : 4, C_6H_3 (COOH) (NH_2) : (NO_2)= *1 : 2 : 5 or 1 : 2 : 4;* and *the 2 : 7-napthylamine sulphonic acid* can be replaced by 2-napthylamine di- or tri-sulphonic acids; further *sulpho anthranilic* acids such as C_6H_3 *(COOH)* : (NH_2) : (SO_3H)= 1 : 2 : 5 or 1 : 2 : 4 can be coupled with 2-napthylamine.

Lakes.—Barium, calcium, and aluminium lakes can be prepared *from the above-described chromium compounds;* the compound of the example yields pure reddish-violet lakes fast to water, lime and light.

Messrs. Rayner & Co., will obtain printed copies of the published specifications and will forward on post free for the official price of 1/- each.

NOTICES.

EDITORIAL.—All Literary communications and Books, Chemical Apparatus, &c., for review or notice to be addressed to the EDITOR.

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THE Owners of British Patent No. 113086 entitled: "SOAPS AND CLEANSING AGENTS FOR USE IN LAUNDRIES" desire to dispose of the Patent or to enter into working arrangements with a firm likely to be interested.

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THE CHEMICAL NEWS.

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LINE ENTITIES AND LINE DOMAINS

PART I.

By F. H. LORING.

THE physical and chemical worlds, if a distinction thus be made, cannot be built up entirely of atomic entities—electricity, in the electronic sense, included. Nor can the atomic world be constructed without something beyond the nuclear part of the atom. This *something* may be summed up by the term *atomic domain.*

Magnetism and static electricity are best comprehended by the scheme of lines of force. The atomic structures are known to be electric in character. Radio-activity reveals clearly the electrical architecture. Thus there are *atomic nuclei, atomic domains* and *lines of force.*

Everyone who has given these matters thought must have wondered whether the lines of force are not themselves incomplete without some sort of domain—a kind of line domain. It is true that one speaks of a *tube* of force, but this does not exactly involve the domain idea as derived by analogy from the atom. These atomic domains seem to restrict the interpenetration of those atoms adjacent to each other (see W. H. Bragg's paper in the *Phil. Mag.*, 1920, xl., 169).

Passing now to the problem of radiation, there is a lack of continuity observed when studying the behaviour of radiant energy and Planck's universal quantum constant known as h has become an important factor in formulating radiation phenomena; that is to say, it is expressed in bundles of h, so to speak, to agree with experiment. Radiation is not, however, strictly speaking, a process that can be truly described as atomic. It seems to identify itself with lines of force, since Hertz waves are nothing other in principle than light waves of great length, in which case lines of force are in marked evidence when considering the electrical aspect of the phenomenon.

A serious difficulty arises in this case; for if light is essentially tremors transmitted along definite lines of force, one has only to examine the wave-front some distance from the light source to expect to find proof of points of light widely spaced. No such effect has been found, although experiments have been made with the object of detecting such separated quanta or such spaced lines in vibration, assuming the line-undulation idea to constitute radiation (see in this connection CHEMICAL NEWS, 1920, cxx., particular pages 195 and 196).

It is true that the Hertz waves are not necessarily interpreted exactly in this way, for the orthodox conception of lines of force coming into existence and disappearing again involves magnetically the lines springing from a point and expanding into larger and larger circles, then contracting into smaller and smaller circles until they cease to exist; but this may be a sort of resultant effect, as if the lines already existed in space in a neutralised state, and when a wave is started this neutralisation is destroyed and it passes out as if it were an expanding line circle of force, whereas the radial line may simply convey the wave (see CHEMICAL NEWS, 1917, cxvi., 181).

Returning to the atomic domain conception, this seems to be in harmony with Bohr's theory of the hydrogen atom, in which circumstance the domain-size of the atom is defined by the radius of the electron orbit, and under conditions of great freedom a very large atom should result. It will be remembered, moreover, that according to the views advanced by Langmuir, in developing the octet theory, "the large atomic volumes of the alkali metals are due to the volumes occupied by single free electrons rather than to a large volume of the atom as such."

It is, of course, the movement of the electron in the atom which is supposed to give rise to radiation, and according to Bohr's theory this takes place when the electron passes from an orbit of radius A to one of less radius, B the energy given out as radiation being in multiples of h, Planck's constant $6{\cdot}55 \times 10^{-27}$ erg × second, so that $A - B = h\nu$, ν being the frequency of the radiation. In this case the positive nucleus of the atom is the sun, as it were, to the planetary system having one planet, the electron, in the example of the hydrogen atom. Sommerfeld has accounted for the fine-line structure of the hydrogen series lines by assuming that the electron describes elliptical orbits, as owing to its increase in velocity at the times when it passes closer to the nucleus it suffers a change in mass according to the theory of relativity. At any rate, the positive nucleus of practically point magnitude (according to Rutherford) serves to anchor the electron.

In a similar way, that is to say, by analogy, the extended line of force may serve to anchor the domain exterior to it—assuming such a domain. If now this domain partakes of the vibration of the line and the expanding wave-front involves expanding unit-domains, then there need be no discontinuity as would be the case if there was no line domain. Such a line domain taken as a single unit would be a cone formed round an axial line of force.

So far, so good; but problems arise. It is difficult to conceive all space filled with such lines and their domains. Moreover, it would be expected that such a complex of lines and their domains would in some way be linked up with gravitational fields existing round bodies (see CHEMICAL NEWS, 1917, cxvi., 181). It is at this point that the mathematician has the advantage over those who adhere rather closely to models; for the former can proceed to evaluate quantities and formulate their action or interaction along such lines as agree with experimental results. He may not be able to picture what his equations represent in terms of mechanism, but he may nevertheless deduce laws agreeing with experiment. The theory of relativity in its extended form assigns to space peculiarities usually associated with matter; or the geometry of space becomes endowed with physical properties. This has proved to be a great help in the solution of difficult problems. As an example, the following from a recent article of mine will serve as an illustration. "Passing over considerable ground and turning to the culminating achievement of the

theory in its more extended form . . . the bending (or drawing-in, in the sense that converging railway lines would bring the trains closer together) of the course of light in passing close to the sun, owing to the concentration of the space-gravitational field (by analogy, the railway-lines) round this massive body (due to the mass-energy of the sun, as it might be termed), was clearly foreshadowed quantitatively by a development of the theory, and the phenomenon was verified by the photographs taken at the last eclipse expedition (see CHEMICAL NEWS, 1920, cxxi., 277)".
(see CHEMICAL NEWS, 1920, cxxi., 277)". The fact that all bodies fall with the same acceleration in a vacuum fits in perfectly with the idea of a field, just as a light shunting engine would follow the same track-course as a heavy goods-train locomotive, in the foregoing analogy; but examples of this kind cannot be pressed to extremes.

If now the principle underlying relativity be grasped, it will be seen that the line domain idea can be treated possibly in a similar manner, and as a result, the complexity referred to above may not involve such a hopeless maze of unresolvable entities as to resist mathematical analysis.

It will, therefore, be desirable to review briefly the main features of relativity. In the first place, the interaction of attracting bodies and their relative movements as developed by Newton, involve by analysis the conception of a fixed background of space and time, and so far as the movements of bodies in what might be termed a self-contained system* are concerned, no difficulty arises, but problems arose in which the self-contained idea in the wide sense became inoperative; that is to say, movements were known which did not agree with the older theory. This fact brought into prominence the principle known to mathematicians: that complex phenomena can be resolved into working components each one of which obeys an invariant law under the conditions specified, and when dealing with such phenomena it became necessary to define what is really meant by relative effects or relative motions. In this newer idea it became necessary to treat all observed phenomena as *appearing* differently to different observers if they were in relative movement with respect to one another; or simplifying matters by considering *two* bodies or systems in relative movement implying observers attached to each system, the words *each other* would be substituted for *one another*. In short, each system in movement had attached to it its own Euclidean -space framework of three dimensions. When two such frames of reference were in relative movement with respect to each other, it became necessary to define the *observer's* view. To do this, it became also necessary to show how the two systems could be related to each other so that each observer could determine consistently the peculiarities of the system he was observing—the one, say, in relative movement with respect to his own. This was accomplished by making use of what is known as the Lorentz transformation equations. These equations are justified, for, by their use answers agreeing with experiment were obtained.

* This term is used in a restricted sense, as when experiments are carried out, for example, on a railway train under uniform straight-line movement. To one stationed on the ground a difficulty would arise owing to the relative movement. This has been thoroughly described in relativity books and it need not be detailed here.

The question of *reality* arises when phenomena are taken as within themselves individually invariant, but relatively variant *to each* other Events which are simultaneous to an observer in may not be simultaneous to another observer in movement with respect to the event being observed. Hitherto the phenomenon was the real thing and all observational formulisation of it the imaginary (image) part. Now the real invariant thing is the law or its formulisation and the imaginary (appearance) part is the phenomenon as observed; but the real part is the small point-time event: the "element" taken complete enough to represent or correspond to the law involved.

It will be seen that by this method the idea of each phenomena (perhaps one should say *its aspect*) when resolved had its own law and in a sense pursued an independent course quite apart from some other phenomenon, which ordinarily would be considered as a part and parcel of it. Differential or conjoint results do, however, arise due to the observer's point of view, but the phenomenon itself is quite independent by analysis, in that it, in common with the neighbouring one, obeys accurately a common law. Dalton's law of partial pressures will serve here as an example "This law states that the pressure due to a mixture of gases is equal to the sum of the pressures exerted by each gas singly when confined in the same space as that containing the mixture" to quote from my "Atomic Theories" (Methuen) p. 5. Here is a case of the interaction of mixed gases without altering the pressure values as obtained by considering each quantity of gas singly, *i.e.*, as if only one gas existed when evaluating its contribution to the total pressure.

Two other examples might be given here. An electrostatic field is an electrostatic field to a stationary observer; but to a relatively moving observer it becomes an electromagnetic field. Here is one fundamental phenomenon having two aspects; or in terms of invariant law each aspect represents the invariant law, which by relative and non-relative movement becomes respectively magnetic and static fields. Gravity and inertia are similarly connected; each is a fundamental "invariant," but according to circumstance the results differ. In one extreme centrifugal force is apparent, in the other, the "apple falling to the earth." One is an inertial effect, the other is a gravitational effect, but these become circumstantial variations of the same fundamental phenomenon. Inertial mass and gravitational mass thus become fundamentally identical.

Now before leaving the relativity method of analysing effects or phenomena, it will be desirable to mention that the three space co-ordinates attached to each system in movement imply also time; but the time so implied is in effect the displacement of one such system with reference to the other; and along with this displacement the idea of space being associated with time (or this time) becomes evident. Or, looking at it in another way, each system has its own time and space, time becoming a fourth dimension in the system.† Moreover, the velocity of light becomes the basic factor in harmonising space and time. In the relativity equations the measurements are

† "The fundamental measurement is not the interval between two points of space, but between two points of space associated with instants of time."—Eddington.

all made with a *constant* appearing in the calculation, which is the velocity of light in a vacuum or space free from matter. Why this particular velocity? This question was raised by Sir Oliver Lodge (see *Nature*, 1921, cvii., 716, 748). For instance, what has the velocity of light to do with the increased mass of the planet Mercury when it sweeps round the sun at its closest approach to this body; *i.e.*, when it moves fastest? We know that by introducing the relativity equations and calculating the increased mass the orbit would be slightly expanded at the perihelion, and, as a consequence, in one hundred years the orbit will have advanced, or rather, turned through an angle of 43 seconds, after allowance has been made for the perturbing effect of the other planets during the century interval.

Here is a purely mechanical problem, apparently, yet the velocity of light is an electromagnetic movement. The answer is that all our mechanics when fundamentally analysed in the ultimate sense involve electrical phenomena, or conversely, all electrical phenomena properly analysed are resolvable into mechanical effects, but the mechanics is the mechanics of Einstein.

Not only do we construct all the elements' atoms out of positive and negative electrons, but we extend their fundamental characteristics to space itself, so that radiation becomes a sort of counterpart to the atomic system, only drawn out linearly and expanded spacially instead of functioning in a circulatory manner.

This brings one now to the line-domain conception, for here in a sense is an actual framework, as it were, extending from points, from atoms say, and this somewhat resembles the fourth dimension figure given in the CHEMICAL NEWS, 1921, cxxiii., 218. Treated in a relativity sense, this becomes a physical frame of reference attached to each moving body—to each atom or atom part—so that space is curved in the Einstein sense if equipotential planes (curved surfaces) are taken across the line domains (see CHEMICAL NEWS, 1917, cxvi., 181). In other words, the curvature of space and the gravitational field therein (see quotation above briefly describing the bending of light) seems compatible with the idea of expanding line domains (see CHEMICAL NEWS, 1915, cxii., particular page 100) so that in effect the lines of force are not of uniform section; and, that which is here considered an important feature, the continuity of the wavefront, follows apparently as a natural consequence.

Considering now the photo-electric effect, the question might be raised: Can such line domains re-concentrate on electrons and account for the photo-electric effect which seems to require more energy than can be obtained from a point in space?

It is well to bear in mind that the discussion of ideas in the foregoing manner involves one in philosophical subleties, but I venture to suggest that the idea of line entities and line domains are not without suggestive interest.

Summary.

By analogy with atomic domains, involving forces which are best expressed as electric line fields, there may be line domains. Such line domains considered from the point of view of relativity seem to follow as a necessary consequence and radiation would thus be rendered continuous at the wave-front. The question is raised as to whether such line domains can re-concentrate on electrons and thereby account for the energy necessary to produce the photo-electric effect? It is felt that philosophical difficulties exist in speculations of this kind, but the ideas in question seem suggestive.

THE ELECTROLYSIS OF AQUEOUS SOLUTIONS OF ALKALINE NITRITES WITH A LEAD ANODE AND AN ELECTRO-METRIC DETERMINATION OF THE CONSTITUTION OF THE COMPLEX ANION FORMED.*

By F. H. JEFFERY, M.A., Trinity College, Cambridge.

THE experiments described in this paper form part of a series of experiments which deal with the passage of electricity during electrolysis from various metallic anodes to aqueous solutions of sodium nitrite.

Reactions which take place with a silver anode and with a copper anode have been described already.

Silver goes into solution entirely as complex anion $(Ag(NO_2)_2)'$ crystals of $Na(Ag(No_2)_2).\frac{1}{2}H_2O$ can be be isolated from the anolyte (*Faraday Soc. Trans.*, 1920, xv., 16).

Copper also goes into solution entirely as complex anion, this anion is $(Cu(No_2)_4)^{iv}$ derived from divalent copper; $K_2Pb(Cu(NO_2)_6$ can be isolated from the anolyte and from this $K_4(Cu(NO_2)_6).2H_2O$ can be prepared (*Ibid.*, 1921, xvi., 453).

The following is a description of that which happens when the anode is of lead:—

Arrangement of Apparatus for Electrolysis.

The cell was a glass dish inside which was a porous pot containing the cathode of smooth platinum, this latter was placed so as not to touch the bottom of the pot. The anode was of area 50×2 cms.², it was bent into a cylindrical shape so as to stand on the bottom of the glass dish, a glass stirrer turned by a motor revolved rapidly close to it. The dish and its contents were placed in a large vessel of water, thereby maintaining the temperature of the anolyte at 17° to 18°.

When the electrolysis had to continue for many hours, it was necessary to suppress the migration of hydroxidion through the cathode pot to the anolyte. This was done by placing the cathode pot inside another porous pot of about double its diameter, the space between the two pots being filled with an anolyte solution which had been obtained from previous electrolysis. Outside this larger pot was the anolyte which was being investigated.

The sodium nitrite used was free from chloride and contained 99·0 per cent pure $NaNO_2$, the rest being sodium nitrate.

The anolyte solutions were of various concentrations from 6·9 grms. sodium nitrate per 100 grms. water to 27·6 grms. sodium nitrite per 100 grms. water. The volume of the anolyte was 200 cc.

* Read before The Faraday Society, November 28, 1921.

The currents varied from 0·099 amps. to 0·77 amps.

Pure lead was used for the anode; Col. C. T. Heycock most kindly gave many hundred grms. of the metal from a stock of pure material which he had prepared for his own use.

The liquid in the cathode pot was a solution of sodium nitrite of the same concentration as that used for the anolyte.

General Effects.

For variations of current and of concentration of sodium nitrite within the limits stated, lead was never deposited on the cathode, although some of the electrolyses continued during more than 24 hours.

The lead went into solution at the anode, forming a complex which gave a bright orange colour to the anolyte This latter was not at any time acid to indicators, nor was any gas evolved at the anode.

The complex lead anion was derived from divalent lead; sodium hydroxide added to the anolyte gave a white precipitate soluble in excess; when hydrogen peroxide was added and then sodium hydroxide a chocolate precipitate of lead peroxide was formed. A solution of sodium sulphate gave a precipitate of lead sulphate.

A solid formed at the anode and adhered to it, but the electrical resistance of the cell was not affected appreciably thereby. This solid consisted of lead nitrite mixed with finely divided lead, the latter could be isolated easily by means of very dilute acetic acid.

Apparatus for Measuring the Anode Potential during Electrolysis.

For these measurements a cadium cell and a potentiometer of the "Granta" type by Messrs. Pye were used. The normal electrode was Ag | AgCl, nKCl | , the diffusion potential was suppressed by concentrated ammonium nitrate solution, the syphon tube connecting this solution with the anolyte being filled with sodium nitrite solution of the same concentration as that used for the anolyte.

Two normal electrodes were used, each dipping into the same ammonium nitrate solution, one of these was kept as a standard with which to compare the other, which was used for the electromotive force measurements.

The anolyte was stirred continuously during all measurements.

Pure sodium nitrite free from nitrate was used for the anolyte and for filling both the porous pots.

The normal electrodes, ammonium nitrate vessel and electrolytic cell were placed in a thermostat containing 92 litres of water. This was heated by gas, delivered at constant pressure from a regulator. The regulation of the temperature was effected by the expansion of alcohol contained in a lead pipe 14ft. long and ⅜in diameter, which was bent into a helix, reaching from the bottom of the water to within about 9 cms. of the top. The water was stirred vigorously.

By these means the temperature was maintained at 18° ±0·003°.

The Anode Potential during Electrolysis.

The electromotive force of the combination was taken with the current on and then immediately *after the current* was off; after each pair of measurements the lead anode was washed with dilute nitric acid and with water and dried.

The lead anode was the negative pole of the combination.

(i.) An anolyte four times weight normal with respect to sodium nitrite containing 1·39 grm. of lead per 100 cc. of the solution :—

Current in Amps.	E.M.F. in Volts, Current on Ag+to Pb.	E.M.F. in Volts, Current off, Ag+to Pb.
0·099	0·5451	0·5481
0·19	0·5451	0·5481
0·29	0·5426	0·5471
0·38	0·5431	0·5471
0·48	0·5451	0·5481
0·58	0·5451	0·5481
0·67	0·5421	0·5481
0·77	0·5411	0·5481

The mean value of E.M.F. current on was 0·544 volts.

The mean value of E.M.F. current off was 0·548 volts.

Taking the potential of the normal electrode at 18° to be 0·5130 volts, the silver being positive to the solution, the following results were obtained :—

The mean value of anode potential current on −0·031 volts.

The mean value of anode potential current off −0·035 volts.

(ii.) An anolyte four times weight normal with respect to sodium nitrite containing 2·55 grms. of lead per 100 cc. of the solution :—

Current in Amps.	E.M.F. in Volts, Current on, Ag+to Pb.	E.M.F. in Volts, Current off, Ag+to Pb.
0·099	0·5350	0·5375
0·19	0·5325	0·5375
0·29	0·5345	0·5375
0·38	0·5345	0·5375
0·48	0·5345	0·5375
0·58	0·5325	0·5375
0·67	0·5335	0·5375
0·77	0·5315	0·5365

The mean value of E.M.F. current on was 0·534 volts.

The mean value of E.M.F. current off was 0·538 volts.

These results gave :—

The mean value of anode potential current on −0·021 volts.

The mean value of anode potential current off −0·025 volts.

From these measurements it appears that the degree of dissociation of the complex lead anion must be very small under these conditions; for a wide range of current nitensity the concentration of plumbous ion remains constant and low, the rate of work involved in the transfer of electricity from anode to anolyte in contact with it being simply proportional to the current.

There is no evidence from these two series of measurements that more than one species of complex is formed.

The Anode Potential during Electrolysis of Solutions containing both Nitrate and Nitrite.

Two series of measurements at 18° were made with four times weight normal solutions of sodium nitrite to which sodium nitrate had been

added. The object was to find whether the anode potential would rise and the anode react with the NO_3 ions present forming plumbous ions in concentration sufficient to give a deposition of lead on the cathode.

(i.) An anolyte four times weight normal with respect to sodium nitrite containing 1·50 grms. of lead per 100 cc. of the solution, to which were added 8·7 grms. of sodium nitrate.

Current in Amps.	E.M.F. in Volts, Current on, Ag+to Pb.	E.M.F. in Volts, Current off Ag+to Pb.
0·099	0·5349	0·5399
0·19	0·5349	0·5389
0·29	0·5349	0·5399
0·38	0·5339	0·5399
0·48	0·5349	0·5399
0·58	0·5349	0·5399
0·67	0·5344	0·5399
0·77	0·5349	0·5399

These results show that the anode potential remained constant for the same range of current intensity as that used for nitrite alone, being −0·022 volts with the current on and −0·027 volts with the current off.

(ii) An anolyte four times weight normal with respect to sodium nitrite containing 2·95 grms. of lead per 000 cc. of the solution, to which were added 8·7 grms. of sodium nitrate.

Current in Amps.	E.M.F. in Volts, Current on, Ag+to Pb.	E.M.F. in Volts, Current off, Ag−to Pb.
0·099	0·5287	0·5307
0·19	0·5292	0·5312
0·29	0·5292	0·5312
0·38	0·5292	0·5312
0·48	0·5292	0·5312
0·58	0·5287	0·5312
0·67	0·5287	0·5312
0·77	0·5277	0·5307

These results are similar to those in (i.), the anode potential being −0·016 volts with the current on and −0·018 volts with the current off. The average rate of work involved in the transference of electricity from anode to anolyte in contact with it is of the same order as that in the two previous cases where no nitrate was present, it is likewise proportional to the current. The presence of the nitrate does not cause such an increase of the concentration of plumbous ion at any current intensity as to give a deposition of lead on the cathode.

Determination of the Constitution of the Complex Anion by Means of Potential Measurements.

The electromotive force E volts of the combination Ag | AgCl, nKCl | cone solution $AmNO_3$ | anolyte | Pb was measured, the total concentration of lead [M] grm. atoms per litre of the anolyte solution was small. Representing the complex lead anion by $Pb_x(NO_2)_y$ and assuming that the law of mass action is applicable to the dissociation of the anion

$$[Pb_x(NO_2)_y] = K[Pb'']^x[NO_2']^y$$

also $E = c - 0{\cdot}029 \log [Pb'']c$ being independent of variations of [Pb''].

Hence—

$$\log [Pb_x(NO_2)_y] = \log k + x\left(\frac{c-E}{0{\cdot}029}\right) + y \log [NO_2'] \quad . \text{ (i)}$$

In a series of measurements to find x the concentration of NO_2' was kept sensibly constant by using a four times weight normal solution of sodium nitrite. Experiments already described have shown that [Pb''] is very small, hence—

$$[Pb_x(NO_2)_y] = \frac{1}{x}[M]$$

and $\qquad \log [Pb_x(NO_2)_y] = \log [M] - \log x.$

Equation (i.) therefore gives

$$\log [M] - \log x = \log k + x\left(\frac{c-E}{0{\cdot}029}\right) + y \log [NO_2'].$$

Hence for a constant value of $[NO_2']$ E is a linear function of log [M] and x is given by

$$\frac{\delta \log [M]}{\delta E} = \frac{x}{0{\cdot}029}.$$

Hence for such concentrations as satisfy the assumptions by means of which the foregoing equations have been derived the graph of log [M] expressed as a function of E is a straight line from which the value of x can be found at once.

The following numbers were obtained, the lead anode being carefully cleaned before each measurement—

E.	Log [M].	[M]
0·5481	$\bar{2}$·8265	6·706 × 10⁻²
0·5511	0·7392	5·485
0·5531	0·6654	4·628
0·5560	0·5473	3·526
0·5628	0·3132	2·057

The straight line through these five points gives $x = 1·03$.

Hence the complex anion is of the form $Pb(NO_2)_y$.

A series of measurements were made to find y; [M] was maintained constant while $[NO_2']$ varied, but $[NO_2']$ was always much greater than [M], under which circumstances the concentration of the complex anion remained sensibly constant. Hence from equation (i.) E must be a linear function of log $[NO_2']$ and therefore—

$$y = \frac{1}{0{\cdot}029} \cdot \frac{\delta E}{\delta \log [NO_2']} \quad . \quad . \quad . \quad . \text{ (ii.)}$$

If R ohms be the resistance measured when the conductivity cell is filled with one of the sodium nitrite solutions to be used, if η denote the viscosity of this solution relative to pure water, if R_∞ ohms is the resistance measured when the same cell is filled with a very dilute solution of sodium nitrite of concentration c_∞ grm. formula weight per litre of solution, then $[NO_2'] = \eta R_\infty c_\infty / R$ where the degree of ionisation is assumed to be given by the Arrhenius formula.

Hence—

$$\log [NO_2'] = \log \left(\frac{\eta}{R}\right) + \log R_\infty c_\infty$$

and therefore—

$$y = \frac{1}{0.029} \cdot \frac{\delta E}{\delta \log \left(\frac{\eta}{R}\right)} \text{ . from equation (ii)}$$

This method of analysis is quite general and avoids the trouble of finding the resistance of solutions of great dilution, with the possibility

of large error due to hydrolysis. The graphical method of finding the partial differential coefficients makes it easy to see whether the limits of concentration, for which the equations are valid, have been passed.

The solutions of sodium nitrite employed for finding y were of concentrations 3, 3·5, 4, 4·5, 5 times weight normal.

The viscosities relative to water at 18° were found by means of a glass viscosimeter shaped somewhat as the instrument described by Washburn (*Jour. Am. Chem. Soc.*, 1913, xxxv., 739); the capillary was 19·5 cms. long, with internal diameter 0·0556 cm.; the volume of liquid flowing through the capillary for each experiment was approximately 6·7 cc; the specific gravities of the nitrite solutions were found relative to water at 18° by means of an Ostwald pyknometer.

Normality of Solutions.	Time of Flow in Seconds.	Specific Gravity	Relative Viscosity η.
water	1000		
3	1168	1·1189	1·2953
3·5	1213	1·1374	1·3674
4	1264	1·1535	1·4450
4·5	1323	1·1681	1·5317
5	1378	1·1837	1·6166

The water used as standard of comparison was of conductivity $1·39 \times 10^{-6}$ reciprocal ohms; it was made from a good distilled water of conductivity about $7·8 \times 10^{-6}$ reciprocal ohms by boiling this latter briskly at 30° whereby the dissolved carbon dioxide was eliminated for the more part. This method was adopted at the suggestion of Col. Heycock.

The resistances of the nitrite solutions were found by Whetham's method, using a post-office box, galvanometer, and rotating commutator. The box and commutator were by Messrs. Pye. The commutator was driven so as to reverse the current 1360 times per minute.

Normality of Solutions	Resistance R in Ohms	$\overline{\text{Log}} \left(\frac{\eta}{R}\right)$
3	14·84	$\bar{2}$·9409
3·5	13·72	$\bar{2}$·9985
4	12·96	$\bar{1}$·0473
4·5	12·46	$\bar{1}$·0896
5	12·06	$\bar{1}$·1273

The electromotive forces of the combinations made from these solutions were measured, when each contained the same small total concentration of lead. Pure lead nitrite was prepared, and, as a preliminary series of experiments made it seem probable that the value of y was 4, both lead nitrite and sodium nitrite were added to each solution, for every grm. formula weight $Pb(NO_2)_2.H_2O$ added to a solution two grm. formula weights. $NaNO_2$ were also added.

Normality of Solutions.	E.M.F. in Volts.	$\overline{\text{Log}} \left(\frac{\eta}{R}\right)$
3	0·5304	0·9409+2
3·5	0·5376	0·9985
4	0·5436	1·0473
4·5	0·5484	1·0896
5	0·5554	1·1273

If E be plotted as a function of log $\left(\frac{\eta}{R}\right)$ it will be found that the points for the first four solutions lie almost exactly on a straight line but that the point for the five times normal solution lies off this straight line.

This may be due to an error of experiment; it seems curious that equation (ii) should be valid for concentrations of sodium nitrite up to 4·5 normal but be inapplicable to the 5 normal solution.

The straight line determined by the first four points gives $y = 4·04$.

Hence the complex anion is of the form $Pb(NO_2)_4$ for solutions containing a total concentration of lead of the order 9×10^{-2} grm atoms per litre of solution and for solutions of smaller concentration.

The Solids which can be obtained from the Anolytes of Various Concentrations.

(i) A 1·5 times weight normal solution of sodium nitrite was used, the electrolysis was continued until 16 grms. of lead per 100 cc. of anolyte went into solution. By evaporation in an exhausted desiccator over concentrated sulphuric acid at a temperature of 16° to 18° large light orange yellow crystals were obtained.

These had the reactions of a nitrite and of lead. The lead was estimated as sulphate. The percentage of lead found was 65·19, the calculated percentage of lead in $Pb(NO_2)_2.H_2O$ is 65·31.

Hence the crystals were lead nitrite.

This seems to be a good method of preparing pure lead nitrite.

(ii) A once weight normal solution of sodium nitrite was used and 8 grms. of lead per 100 cc. of anolyte were put into solution. In this case also crystals of the same appearance were obtained, the temperature during evaporation being 16° to 18°. The percentage of lead found was 65·22. Hence these crystals were lead nitrite.

(iii) A four times weight normal solution of sodium nitrite was used and 5 grms. of lead per 100 c. of anolyte were put into solution. The temperature during evaporation was 16° to 18°. White crystals of sodium nitrite were obtained.

(iv) A four times weight normal solution of sodium nitrite containing 15 grms. of lead per 100 cc. of anolyte was treated as before, the conditions of temperature being the same. Crystals of sodium nitrite were again obtained.

An isothermal equilibrium curve could be constructed for the system lead nitrite—sodium nitrite—water by taking as abscissæ the weights of sodium nitrite per 100 grms. water and as ordinates the weights of lead nitrite per 100 grms. water. The results described in (i) to (iv) indicated that the curve might consist of three portions, the first portion representing solutions in equilibrium with lead nitrite as solid phase, the third portion solutions in equilibrium with sodium nitrite as solid phase and a middle portion representing solution in equilibrium with a solid which might be the sodium salt of a lead complex. A necessary condition for this would be that this solid phase should be stable at the temperature of isothermal evaporation in the presence of the liquid phase. Solutions of the following initial concentrations were evaporated in an exhausted disiccator over concentrated sulphuric acid at 16° to 18°:—

(*a*) 4·5 times weight normal sodium nitrite containing 33 grms. of lead per 100 cc. of solution.

(*b*) Twice weight normal sodium nitrite with 12grms. of lead per 100 cc. of solution.

(*c*) Four times weight normal sodium nitrite containing 17 grms. of lead per 100 cc. of solution.

In each case crystals were obtained, but these were not homogeneous.

A further experiment was made with an anolyte four times weight normal with respect to sodium nitrite, the sodium nitrite was free from nitrate, the electrolysis was continued until the resulting solution contained 20 grms. of lead per 100 cc. This was evaporated isothermally in an exhausted desiccator surrounded with ice. Crystals were obtained, but these also were not homogeneous.

It seems that under the conditions of the experiments just described no solid phase such as $Na_2(Pb(NO_2)_4)$ exists in stable equilibrium with nitrite solutions containing the plumbo nitrite complex.

The Electrolysis of Solutions of Potassium Nitrite.

It seemed possible that a potassium salt corresponding with the complex might be easier to isolate in the solid state. A series of experiments were made with solutions of potassium nitrite. Sticks of this material were used and therefore potassium nitrate was present in the solutions. The concentrations of the solutions were approximately normal, twice normal and four times normal by weight.

Just as with sodium nitrite the lead went into solution at the anode forming a complex which gave a bright orange colour to the anolyte, no gas was evolved at the anode, no trace of metal was deposited on the cathode. There seemed no reason to suppose that the lead complex in solution was other than that already described.

The Solids Obtained from Potassium Anolytes.

By evaporation in an exhausted desiccator over concentrated sulphuric acid crystals were obtained; these were transparent needles often four to five centimetres long, of a bright orange colour. Their appearance was homogeneous and suggested either a chemical individual or solid solutions.

When heated they evolved nitric peroxide and water; they gave the reactions of a nitrite, of lead and of potassium They always contained a nitrate; this was found by acting on an ice-cold concentrated solution of the crystals with excess of hydrazine sulphate added as a fine powder, filtering free from lead sulphate and then adding "nitron" acetate solution.

The results of analysis of various specimens of these crystals are tabulated: the lead was estimated as sulphate, the potassium as sulphate, the NO_2 by means of potassium permanganate, the NO_3 as "nitron" nitrate. The water was not estimated.

In the tables the first columns give the percentages of the metals and the acid radicals, the second columns give these percentages divided by the respective formula weights.

(i) *From a normal solution of potassium nitrite containing 8 grms. of lead per 100 cc. after electrolysis*:—

NO_2	35·94	0·781	
Pb	48·11	0·232	$[NO_2]/[Pb]=3·36$
K	13·30	0·340	
NO_3	1·23	0·020	

(ii) From a twice normal solution of potassium nitrite containing 12·5 grms. of lead per 100 cc. after electrolysis—

NO_2	30·55	0·705	
Pb	47·85	0·231	$[NO_2]/[Pb]=3·44$.
K	12·96	0·332	
NO_3	1·10	0·018	

(iii) From a four times normal solution of potassium nitrite containing 5 grms. of lead per 100 cc. after electrolysis—

(*a*) First crop of crystals—

NO_2	37·82	$[NO_2]/[Pb]=3·70$.
Pb	46·06	

(*b*) Second crop of crystals taken from mother liquor of (*a*) twenty hours later—

NO_2	38·58	$[NO_2]/[Pb]=4·15$.
Pb	41·90	

(*c*) Third crop of crystals taken from mother liquor of (*b*) twenty hours later—

NO_2	39·43	$[NO_2]/[Pb]=4·96$.
Pb	35·80	

These results show that from solutions containing potassium nitrite, potassium nitrate and the plumbo nitrite complex a series of solid solutions can be formed in equilibrium with liquid phases. These solids are transparent crystalline bodies far less soluble than potassium nitrite and lead nitrite.

There is no evidence that definite chemical individuals of the nature of "triple salts" are produced.

Inasmuch as no lead was deposited on the cathode nor found in the catholyte during any of these electrolyses, the cationic complex $(KPbNO_2)$ described by W. K. Lewis (*Dissert.*, Breslau, 1908) was not formed under the conditions of these experiments.

The percentage of NO_3 in the crystals obtained as described above was small. An experiment was made to find whether similar crystals could be obtained from a solution containing a far higher concentration of potassium nitrate and also to test whether the complex derived from a sodium nitrite anolyte would behave in the same way as one derived from a potassium nitrite solution of approximately the same concentration.

A twice normal solution of sodium nitrite was electrolysed until it contained 12 grms. of lead per 100 cc. Potassium nitrate was added to this so that every 100 cc of the anolytes dissolved 10 grms. of the nitrate.

Crystals of precisely similar appearance were obtained under the same conditions of evaporation. Two crops were analysed, the second being taken from the mother liquor of the first some forty hours later.

(*a*)	NO_2	26·90	0·585	
	Pb	41·46	0·200	$[NO_2]/[Pb]=2·92$.
	K	15·65	0·400	
	NO_3	14·79	0·238	
(*b*)	NO_2	24·74	0·538	
	Pb	40·72	0·197	$[NO_2]/[Pb]=2·74$.
	K	15·53	0·397	
	NO_3	17·27	0·278	

A series of solid solutions is formed here also.

Discussion of Results and Summary.

The plumbo nitrite complex is $(Pb(NO_2)_4)''$ for small concentrations of lead in alkali nitrite solutions. The anode potential measurements for increasing current make it probable that this is the only complex formed; if a second species of complex derived from $Pb(NO_2)_2$ and NO_2 ions were formed, the anode potential should be different from what it is with $(Pb(NO_2)_4)$ for the same total concentration of lead owing to difference in degree of dissociation of the complex anion; such a difference in the nature of the reaction of the anode would probably be accompanied by an abrupt change in curvature of the anode potential—current curve: the measurements given above afford no indication of such a change.

The solid in equilibrium with solutions obtained from anolytes of certain concentrations is lead nitrite crystals $Pb(NO_2)_2.H_2O$. The colour of these crystals is approximately the same as that of the solutions from which they are derived, it is not that to be expected from a consideration of the majority of salts derived from divalent lead. If, however, the plumbo-nitrite complex maintains its identity in these crystals, their colour is that which is probable from their origin.

It seems that a direct way of testing this hypothesis would be by an X-ray analysis of the crystals; the $(Pb(NO_2)_4)$ group should form a pattern regularly repeated in three dimensions relative to the cationic Pb atoms its identity being as well defined as that of the CO_3 group in a crystal of $CaCO_3$, which latter has been shown by the investigations of Prof. W. L. Bragg.

The solid solutions obtained from aqueous solutions containing the ions K, NO_3, NO_2, and the plumbo-nitrite complex are also coloured orange but more red than the urage of lead nitrite. It may well be that the complex exists as a definite atomic group in these crystals also.

Lead forms compounds in which it is divalent and others in which it is tetravalent. The complex formed in these electrolyses is derived only from divalent lead. Silver and copper anodes also give anionic complexes with NO_2 ions derived in each case from metallic ions of only one valency. Nevertheless it is possible for electricity to pass from the anode to anolyte with the simultaneous formation of complexes derived from two species of metallic ions. A gold anode with nitric acid as anolyte gives an example of this (*Faraday Soc. Trans.*, 1916, xi., 172): when the acid is concentrated both auric and aurous anionic complexes are formed; below a certain concentration only auric anions are obtained. It is intended to examine the reaction of a gold anode with sodium nitrite solutions to see if similar effects are produced.

Further experiments are in progress with other metals and nitrite solutions.

I am again much indebted to the Goldsmiths' Reader in Metallurgy, Col. C. T. Heycock, M.A., F.R.S. The admirable facilities he has given me, his continued interest in the course of the experiments, increase my gratitude to him for the privilege of working in his department.

The Goldsmiths' Metallurgical Laboratory,
Cambridge.

THE "THERMOS" FLASK IN THE CHEMICAL LABORATORY.

By CLAUDE W. BOURLET and WALTER THOMAS.

It is not, apparently, generally recognised how useful an ordinary Thermos flask may become in the laboratory.

The Dewar vessel is, of course, universally employed for the storage of liquefied gases and other liquids boiling at low temperatures, or in other experiments where the maintenance of low temperatures is desirable. Chemists, however, do not appear to have exploited to the full the power of the vacuum flask of maintaining substances at temperatures above the normal.

This note will endeavour to point out a few cases in which this property may be utilised.

(1) *Reactions between liquids at elevated temperatures.*—Providing the reaction is not too strongly exothermic, it may be carried out conveniently in a Thermos flask or Dewar vessel. The mixture of liquids is heated to the desired temperature, poured into the insulated chamber, and left till the reaction is complete. This technique has been found particularly useful in the oxidation of organic compounds with $KMnO_4$. The same method—with appropriate modification—is obviously applicable to solid-liquid reactions. If gases are evolved, a vent must be provided.

(2) *The separation of emulsions.*—Oil-water emulsions and similar mixtures are conveniently "split" by warming and standing over night in a Thermos flask.

(3) *The separation of colloidal and flocculent precipitates.*—Flocculent precipitates "settle out" much more rapidly at elevated temperatures. Similarly, colloidal precipitates (*e.g.*, $BaSO_4$) become granular and easily separable by the same treatment. The technique is obvious.

(4) *Colour reactions.*—In certain colour tests," (*e.g.*, the Halghen reaction) the colour is only developed at temperatures above normal. In this case too, the vacuum flask becomes a great space and labour saver.

(5) *Reactions in gelatinising media.*—Occasionally it is necessary to carry out reactions in media which gelatinise or become extremely viscous at ordinary temperatures. Here again, the Thermos flask can replace the more cumbersome water-bath with advantage.

Finally, it may be pointed out that—at a pinch—a portable incubator for bacteriological work may be improvised from the ever-useful Thermos.

The Bourlet-Thomas Research Laboratories,
24, Richborough Road,
Cricklewood, N.W.2.

BRITISH CHEMICAL STANDARD STEEL "A2."

(Analytically Standardised Sample.)

There is now ready for issue a new steel which of special value both as a dead mild analytical standard very low in impurities, and also a "pure Iron" sample for standardising bichromate and other volumetric solutions.

The analyses have been undertaken as usual by a number of experienced chemists both in the

United Kingdom and U.S.A. representing the following interests: British Government Department; U.S. Bureau of Standards; Referee Analysts—Independent; Railway Analysts—Representing users issuing specifications; Works Analysts—representing makers and users.

The standard figures are as follows:—

Carbon Steel "A2."

Carbon (combined) ...	0·039
Silicon	0·036
Sulphur	0·020
Phosphorus	0·008
Manganese	0·043
Arsenic	0·031
Nickel	0·06
Chromium	0·013
Copper	0·065
Oxygen	0·04
Iron (by difference) ...	99·64

The standard turnings may be obtained in 500, 100, or 50-grm. bottles, either direct from Organising Headquarters, 3, Wilson Street, Middlesborough, or through any of the leading laboratory furnishers at a price just sufficient to cover the cost. A certificate giving the names of the analysts co-operating, the types of methods used, and a detailed list of the results, will be supplied with each bottle.

A NEW PROCESS FOR HYDROGENATION OF ORGANIC COMPOUNDS AND MORE ESPECIALLY FATS AND OILS.

THE essential feature of this process invented by A. Granichstadten and Dr. E. Sittig is the employment of a double silicate of magnesium and nickel, a compound which gives remarkably good results. In hydrogenation with this catalyser, the oils, even at a temperature of only 35 to 40° Celsius, acquire an unusual degree of whiteness. With most of the known methods, the dark oils utilised for alimentary fats must be first or subsequently bleached, the oils hydrogenated by the new process are perfectly white, and ready for manufacture of alimentary fats.

The catalyser is prepared by precipitation of the double silicate so as to obtain as uniform a product as possible. Judging from the results of experiments, this process will soon occupy a high rank amongst those now utilised. Applications for patents have already been made in most countries, and in some cases granted.—*Giornale di Chimica*, October, 1921.

CHLORINE CELLULOSE.

THE analytic method, given by Cross and Bevan, to separate and estimate cellulose in plants, boiling the fibrous matter with a diluted solution of sodium hydrate, then, after washing, treating it with gaseous chlorine, and finally with a boiling alkaline solution, this method, suitably adapted, has passed out of the laboratory into industry. The problem was solved by an Italian inventor, Beniamino Cataldi, who, after long study and experiments, took the first patent in 1915 for a process to manufacture cellulose with humid gaseous chlorine, this being followed by two others. In this same year, 1915, a company was formed for construction of an experimental works on an industrial scale at Polonghera (Cuneo), this company being subsequently transformed into the Societa Anonima Cellulosa, Polonghera. A very pure, white cellulose is now obtained from poplar wood, more highly appreciated that that made by the soda process. There is a considerable consumption of chlorine, 28 parts of chlorine per 100 of dry poplar cellulose. Manufacturers of electrolytic soda have long been looking for new markets for chlorine, and the Soc. Elettrochimica Pomilio has now decided to construct a plant at their Naples electrolytic soda works to produce about 10 metric tons of cellulose daily from hemp and Tripolitan esparto. Italy now imports about 800,000 quintaux of cellulose yearly, for which 250,000 of chlorine could be utilised, with the possibility of producing about 280,000 of electrolytic soda, thus meeting all the home requirements of caustic soda. Consequently, adoption of the Cataldi process on a large scale would make imports of cellulose and caustic soda unnecessary. *Giornale di Chimica*, October, 1921.

CONTRIBUTION TO THE SOLUTION OF THE NITROGEN PROBLEM.

THE possibility of recovering a greater proportion of the nitrogen in coal is discused by Sig. G. Gianoli in the *Giornale di Chimica*, who reviews the technical difficulties relating to the distillation of gas in presence of alkaline chlorides or others (Riedel, German patent 298603).

For this process, in fact, all the plant for gas manufacture would have to be radically altered. The nitrogen of coal could thus be totally obtained, it is true, in form of NH_4Cl, but the expenses for alterations in gas works and coke ovens would be very great. The chlorides and hydrochloric acid produced would corrode the condensers and the gas itself contain hydrochloric acid detrimental to heating and lighting appliances. Then the coke would contain a great percentage of mineral matter. The process seems more suitable for poor gas plant.

To conclude, the question of utilisation of the nitric oxide produced in internal combustion engines is examined. Wittfield considers that this could be utilised. This is a new argument in favour of complete distillation of fuels such as lignite and peat in electric works.—*L'Engrais*, November 4.

PROCEEDINGS OF SOCIETIES.

THE FARADAY SOCIETY.

AT the Annual General Meeting of the Faraday Society held on December 13, the following Officers and Council were elected to serve for the forthcoming year. *President*—Prof. Alfred W. Porter, F.R.S. *Past-Presidents.*—J. Swinburne, M.Inst.C.E., F.R.S.; Sir R. T. Glazebrook, K.C.B., F.R.S.; Sir Robert A. Hadfield, Bart. *Vice-Presidents.*—W. R. Cooper; Prof. C. H. Desch; Prof. F. G. Donnan, C.B.E.,

F.R.S.; Dr. J. A. Harker, F.R.S.; E. Hatschek; Prof. T. M. Lowry, C.B.E., F.R.S.; Dr. G. Senter. *Treasurer*—Robert L. Mond. *Council*—Prof. A. J. Allmand; Dr. H. Borns; Cosmo Johns; Prof. J. R. Partington; C. C. Paterson; Dr. J. N. Pring; Prof. W. C. McC. Lewis; Prof. A. O. Rankine; Dr. E. E. Rideal; Sir Robert Robertson, K.B.E.

The Annual Report presented at the Meeting stated that during the year under review, four General Discussions had been held, three of them in co-operation with other societies, and that reports of the proceedings of these Discussions had been published and were in considerable demand.

The work of the Society had greatly expanded and an appeal was made for an increased membership, without which it would be difficult for the Society to keep pace with its increasing acitivities without a higher subscription. Up to the present this has been avoided.

THE OPTICAL SOCIETY.

A MEETING of the Optical Society was held at the Imperial College of Science and Technology on Thursday, December 8, 1921, when the following papers were read and discussed:—

"*The Physical Meaning of Spherical Aberration.*" By L. C. MARTIN.

Experimental determination of the intensity of light near the focus of a lens system showed that the "spurious disc" appearance persisted at the best visual focus, even in the presence of large amounts of aberration. The effect of increasing aberration is to draw light from the central concentration and scatter it in the surrounding field, and, from measurements of the loss, the necessity of restricting the phase residuals to within $\lambda/6$ is inferred. Spherical aberration is found to produce marked asymmetry on each side of the focus, a matter of great importance in some optical instruments.

"*An Auto Stroboscope and an Incandescent Colour Top.*" By Dr. F. L. HOPWOOD.

A description was given of some novel optical phenomena which may be observed when revolving incandescent filaments are viewed. The production of a variety of stationary dark images, due to the eclipse of an incandescent wire by an adjacent cold wire or opaque object, when both are revolving round a common axis, was described, and it was shown how the phenomena might be practically applied to the study of the behaviour of a rotating body, by converting such a body into an auto stroboscope.

A demonstration was given of the use of a spinning incandescent electric lamp as a colour top and for exhibiting after image effects.

"*Achromatic One-Radius Doublet Eyepieces.*" By Lieut.-Col. J. W. GIFFORD.

Eyepieces both of the Huygenian and the Ramsden types have been constructed from pairs of one-radius achromatic doublets with external plane surfaces to the flint lenses They compare well with the German orthoscopes in definition, while the cost of production, since the same radius serves for each doublet, or in the case of the Ramsden throughout, is sensibly less. Such eyepieces are adapted either for the telescope or the microscope. By their use a much more perfect achromatism is obtained, and also in both of them a flat field, and in one of them a very extensive flat field, likely to be useful in such operations as counting blood corpuscles, etc.

CORRESPONDENCE.

GERMAN REPARATIONS IN KIND.

To the Editor of the Chemical News.

SIR,—I enclose for favour of publication a copy of a letter addressed to the Prime Minister on the 9th instant by the Council of the Institution of Electrical Engineers, on the subject of "German Reparations in Kind"—I am, &c.,

P. F. ROWELL, *Secretary.*

The Rt. Hon. DAVID LLOYD GEORGE, O.M.,
P.C., etc., First Lord of the Treasury,
The Treasury, Whitehall, S.W.1.

SIR,—The Council of the Institution of Electrical Engineers have had their attention directed to certain public declarations and Press communications proposing that the German Reparation Indemnity should be partly provided by the construction in this country of generating stations and the carrying out of railway electrification by German contractors; and having appointed a Committee to report to them thereon, desire to put before the Government their considered view on these proposals as follows:—

On the general principle of reparations in kind they have to remind the Government that at the present time when unemployment is so extensive any reparations in kind should be of such a nature that they do not compete with any productions in this country involving employment on a great scale of labour both skilled and unskilled.

With regard to the proposals that large electric power stations should be erected and that railway electrification should be undertaken by German contractors, they desire to make the following observations. It is possible that the proposals for the acceptance of German plant on account of reparations may have existed from a hasty impression that such action would confer benefits on this country in the form of cheaper transport and power. But if such plant is to stand as a contribution towards reparations, its value must be debited to the undertakings using it. In no other way can such value be put to the credit of National indebtedness. There is, therefore, no good reason to suppose that the use of German plant obtained in that way would result in the users of it being able to give a cheaper service than with new equipment of British manufacture.

There are, however, other considerations which my Council desires to urge. The Electrical industry in this country is at the present time suffering from a grave lack of employment in all its branches, but nevertheless many works are being run in the expectation of a trade revival. Should it be decided to accept German machinery on a large scale, there is no doubt

that a large additional amount of unemployment would immediately result, and that both the work-people and technical staffs at present being kept together would be disbanded. Moreover, the effect of the acceptance for the public service of this country of electrical machinery of German manufacture would be a world-wide advertisement for such goods, and would fatally diminish the present prestige of British electrical goods with most serious effects on our export markets.

The experience of the war showed the necessity of this country having a large number of highly skilled and trained electrical engineers available, and the members of the Institution of Electrical Engineers were called upon during the war to undertake work for the national forces requiring the highest skill.

A proposal which would have the effect of crippling many of the most important electrical manufacturing concerns and leaving this country dependent for electrical services upon German industry would result in discouraging the training of electrical engineers for what, in war time, is a vital necessity.

In view of the points briefly set out above, the Council of the Institution of Electrical Engineers representing all branches of the Electrical industry, desire to urge most strongly on H.M. Government the disastrous consequences which would ensue to the industry if electrical construction in this country on an extensive scale is entrusted to German manufacturers. Any possible immediate advantage anticipated by the proposers of the scheme of reparation could not offset the ruin of those industries in this country which are engaged in the manufacture of steam turbine plant and heavy electrical machinery, both of which had their sole origin in British science and inventiveness.

The Council of the Institution trust that in view of the discussions which have been published, H.M Government will remove the great uncertainty which has been created in the industry by an immediate statement that such proposals will not be entertained. If, however, proposals of the kind should be considered by the Government, my Council ask that they should be given an opportunity of being heard by yourself or the Chancellor of the Exchequer before any action is taken.—I am, &c.,

(*Signed*) J. S. Highfield, *President.*

NOTES.

Royal Institution.—The Christmas Lectures adapted to a juvenile auditory will be delivered by Prof. J. A. Fleming on "Electric Waves and Wireless Telephony" on the following dates, at 3 p.m : Thursday, Dec. 29, Saturday, Dec. 31, Tuesday, Jan. 3, 1922, Thursday, Jan. 5, Saturday, Jan. 7, Tuesday, Jan. 10.

The *Journal of the Society of Chemical Industry* for December 15 reproduces an Address delivered by Mr. G. C. Clayton at the Liverpool Section in October last on "Sulphuric Acid Manufacture"; at the conclusion of the Address a few words are given on future prospects which are so hopeful that we take the liberty of reproducing them. "*Prospects.*—With regard to the future, I am unable to take the pessimistic view that our industry will not recover. Dark and uncertain as the future appears at the moment, we must not lose hold of the essentials of our success. What was the position before the war? Industrially, judged from the standpoint of foreign trade, we were apparently in an unassailable position; but it was evident then that the lethargy engendered by a surfeit of prosperity had to be shaken off if we were to maintain our position. But the fact remains that we had achieved that position and held it so long for certain very clear and well-understood reasons. First, we owed it to our geographical position—the clearing house of the old and the new worlds—which made us the trading, banking, and carrying nation of the world. Secondly, we had readily accessible and cheap supplies of coal and iron; withal we were exempt apparently from the dread possibility of Continental warfare, with no great military commitments, and with our huge trade, taxation was comparatively low. But even more important than these, we had the *solid British character—loyal, persevering*, and conscientious. We were the great colonisers of the world; we were in consequence constantly opening up new spheres of influence which meant new markets for the industries of the country; and we were able, under humane and economic conditions, to produce at costs which could compete with *those of other countries*. If we are to continue as an industrial country, costs of production must come down; but that does not necessarily mean that wages must be drastically reduced to below pre-war rates, or that the standard of living need be lowered. What must be reduced is the cost of the unit. *There must be more production per* man, and the greater the production the greater the efficiency, and the greater the chance of success. Our industry is of vital importance to the country. *Its necessity was proved during the* war; it is equally vital in times of peace. We must keep all our industries in the forefront, and *we must largely depend on our chemists to do* this, not only in the chemical industry, but in practically every other. No up-to-date works can afford to be without its chemist, and no chemist is of use unless he continues to study throughout his life."

The British Trade Ship.—We have already called attention to the project of a floating exhibition that is to carry British productions to the chief business centres of the world. The *preliminary arrangements* are *progressing* rapidly and from a budget of particulars just to hand, we are pleased to learn that the costs of production are so far altered that the promoters of the enterprise are able to reduce charges by 33⅓ per cent on account of the fall in costs of British manufacture. This certainly foreshadows *a revival of trade, and there are many other* indications pointing to the same end, which we sincerely hope will continue unchecked.

Hospital Supplies Purchase Board.—The setting up of a Hospital Supplies Purchase Board appears among the recommendations of the New Zealand Hospitals Commission which was appointed to inquire into and report upon

proposals to amend the New Zealand Hospitals and Charitable Institutions Act of 1909. By this means it is believed large economies would be effected through the buying in bulk of drugs and dressings for the whole of the hospitals of the Dominion. The Commission recommended that this Board should include officials from the four base hospitals who have had large experience of buying, two business men, and representatives of the Health and Mental Hospitals Departments. H.M. Trade Commissioner in New Zealand (Mr. R. Dalton) has informed the Department of Overseas Trade that it has been definitely decided to establish a purchase board on these lines although this has not yet been done. It is probable also that buying agents will be appointed in London.

We have received from the Controller of H.M. Stationery Office a copy of the Report of the Discussion on the "Physics and Chemistry of Colloids" held jointly by the Faraday Society and the Physical Society of London. It is a well-printed and very fully illustrated pamphlet of 190 pages, and gives full details of this most important contribution to the knowledge of colloidal physics and chemistry. Interesting papers were contributed by Professors Svedberg, Pauli, Hatschek, Sir Robert Robertson, Dr. Morris Travers, Sir Herbert Jackson, and many other well-known workers in the field. There is an appendix dealing with the Proteins and Colloid Chemistry by Jacques Loeb, and another on the *Internal Pressure of Liquids* by H. Kneebone Tompkins. Copies of the Report are obtainable at H.M. Stationery Office, Imperial House, Kingsway, price 2s. 6d. net.

Grants for Scientific Research in Norway.—In connection with the proposed establishment of funds for scientific research in Norway, H.M. Minister at Christiania reports that grants have now been made for the following purposes: (1) 8000 kroner for experiments to be made in connection with the use of acetylene gas as motor fuel; (2) 24,000 kroner for the purpose of investigation in vitamina with special application to cod-liver oil; (3) 6000 kroner to examine the possibility for employing calcium carbide as a basis for further manufacture in Norway.

The London correspondent of the *Manchester Guardian Commercial*, in a recent issue says: "On good authority I hear that the railway managers have decided to make a substantial reduction in their charges for goods traffic, and that the lower scale will come into operation next month. An official announcement will, I understand, be made in a few days. Passenger fares have also been under consideration, but up to the present no decision has been reached, according to my information. Within the last fortnight representations have been made by a number of commercial organisations for a reduction of railway charges, and several meetings of the managers have been held to consider matters. As I mentioned some weeks ago, certain recommendations were made to the Boards of the various companies, but the directors, with dividends in mind, sent the proposals back to the Railway Clearing House for further consideration on certain points. These, I understand, have now been cleared up, hence the likelihood of early reductions."

New Patents

This List is specially compiled for the *Chemical News* by Messrs Rayner & Co., Registered Patent Agents, of 5, Chancery Lane, London, W.C.2., from whom all information relating to Patents, Trade Marks and Designs can be obtained gratuitously.

Latest Patent Applications.

32152—Calvert, G.—Manufacture of substances containing a methyl radicle. November 30.

32234—Imray, O. Y.—Manufacture of B-thionaphthisatin. Dec. 1.

32564—Laing, B.—Manufacture and utilization of formic acid. December 3.

32335—Plausons (Parent Co.).—Concentration of solutions of colloidal dispersions. December 2.

31818—Strubell, A.—Process for obtaining partial antigenes of pathogenetic bacteria non-resistant against acids. November 28.

32216—Weyman, G.—Neutralization and drying of sulphate of ammonia. December 1.

Specifications published this Week.

163018—Lilienfeld, L. Manufacture of ethers of carbohydrates having the emperical formula $nC_6H_{10}O_5$ such as cellulose, starch, dextrine and the like.

163271—Lilienfeld, L.—Process for the production of oily bodies of high boiling point from aromatic hydrocarbon mixtures.

171722—Cornelius, C. R.—Process of producing zinc or zinc and lead.

171751—Heinemann, K. and Hoesch & Co.—Process for the recovery of pure caustic alkalies from impure lyes.

165759—Hirschel, W. N.—Process for the manufacture of phosphoric acid.

150962—Goldschmidt Akt. Ges.—Process and appartus for the production of alkali sulphate and hydrochloric acid.

Abstract Published this Week

Fluxes.—Patent No. 170343.—A Flux for aluminium has been invented and Patented by Mr. H. V. A. Briscoe, of 32, Blenheim Gardens, Cricklewood, and Richardson, D., of 26, Winterbrook Road, Herne Hill, of the District Chemical Co. Ltd., 1, Fenchurch Avenue, London. The flux which is particularly intended for the autogenous welding of aluminium, comprises one or more alkali halides and an activating agent which reacts with them, only in the presence of aluminium oxide. An alkali pyrosulphate or pyrophosphate is employed as activating-agent, a suitable mixture being potassium chloride 45 per cent, sodium chloride 30 per cent, potassium fluoride 7 per cent, lithium chloride 15 per cent, and the pyrosulphate or pyrophosphate 1 to 10 per cent. The materials are all melted together in a vessel free from metallic oxide soluble in the flux and on solidifying a homogenous mass remains which is powdered.

Messrs. Rayner & Co., will obtain printed copies of the published specifications and will forward on post free for the official price of 1/- each.

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THE CHEMICAL NEWS.

VOL. CXXIII., No. 3220.

CHEMISTRY: THE EVOLUTION OF MATTER.*

By FRANK WIGGLESWORTH CLARKE,
U.S. Geological Survey.

DURING the greater part of the nineteenth century many philosophical chemists held a vague belief that the so-called chemical elements were not distinct entities, but manifestations of one primal form of matter, the *protyle*, as it was sometimes termed. Other chemists, more conservative, looked askance at all such speculations, and held fast to what they regarded as established facts. To them an element was something distinct from all other kinds of matter, a substance which could neither be decomposed nor transmuted into anything else. One fact, however, they ignored, namely, that the elements were intimately connected by many relations, which are best shown in the periodic law of Mendeléeff, who actually predicted the existence of unknown elements which were afterwards discovered. This is ancient history, with which all chemists are now familiar. It became evident to most chemists that the elements must have had some community of origin, for otherwise their relations to one another are unintelligible.

In 1873 I ventured to publish the suggestion (F. W. Clarke, "Evolution and the spectroscope", *Pop. Sci. Mon.*, January, 1873), based on spectroscopic evidence and assuming the nebular hypothesis to be true, that the evolution of the planets from nebulae had been accompanied by an evolution of the chemical elements. The nebulae are chemically simple, the hotter stars more complex, the cooler stars and the Sun still more so, and the solid earth the most complicated of all. This was promptly denounced as heresy; but nearly a year later Lockyer (N. Lockyer, *Proc. Roy. Soc.*, xxi., 513. Paper dated Nov. 20, 1873), put forth an analogous suggestion, based upon the same sort of evidence, but starting from the other end. That is, he assumed that in the hotter stars some elements were dissociated, and his suggesion was received with a good deal of favor. The heresy was beginning to be orthodox. In course of time the discovery of radioactivity by Becquerel and of Radium by Madame Curie established the fact that some, at least, of the elements were really unstable. The evolution of helium from radium, discovered by Ramsay and Soddy, made the evidence for this instability complete; a derivation of one element from another had actually been observed.

These discoveries opened a new field of research; and it was soon found that the elements at the top of the atomic weight scale, namely, uranium and thorium, are spontaneously but slowly decaying, yielding more than thirty new substances which differ widely in the point of stability. To each one a half-life period is assigned, measured in some cases by thousands of years, in others by fractions of a second. Among these are two new varieties of lead; one derived from uranium, the other from thorium, which chemically are not distinguishable from ordinary or normal lead except by differences in their atomic weights and their specific gravities. The lead from thorium has an atomic weight about a unit higher, and that from uranium about a unit lower, than the atomic weight of normal lead. To this class of facts I shall refer later, as evidence in support of my arguments. That chemical elements can decay is the essential fact to be remembered.

That the chemical elements were formed by a process of evolution from the simplest forms of matter can hardly be doubted now, but the process is not yet ended. They were developed at high temperatures; but when a certain stage is reached in the cooling mass they began to combine with one another to form the new class of substances which are known as compounds. These, obviously, represent an advanced degree of complexity, with corresponding instability; and with varying conditions both combinations and decompositions, such as are reproducible by human agencies, constantly occur. By this extension of the evolutionary process the solid Earth was built up, but in principle the process is the same throughout. From the formation of the first elements to the chemical changes now taking place upon the Earth there is no real interruption. One line of progress has been followed until a maximum of natural complexity and instability is reached in the organic compounds which form the basis of all physical life, whether vegetable or animal. The same fundamental matter, governed by the same fundamental laws, appears from beginning to end of the evolutionary process.

Between the formation of an element and the formation of a compound there is, however, an apparent difference The first stage of the process was one which required a vast period of time, the second stage is marked with rapidity. The series of elements was slowly formed, and their rate of decay, as shown between uranium and lead, is also relatively slow. The formation and decomposition of compounds, on the other hand, is rapid; and in some cases their rate is measurable. The distinction is not absolutely definite, for some of the short-lived products of radioactive decay seem to be exceptions to the rule, which in general may be stated as follows: The process of the evolution is characterized by progressive acceleration, being slow at first, and becoming gradually more and more rapid. Its rate of acceleration may not be uniform but the general drift is clear. It follows the line from the simplest substances to the most complex. In all vital processes the ease and rapidity with which compounds are formed and developed is evident, and some of these substances are extremely complicated.

In any attempt to discuss the evolution of the chemical elements we have for guidance some facts and many analogies. That the most complex elements are unstable we have already seen, and it is suspected that all the others follow the same rule. Potassium and rubidium are feebly radioactive, which is an evidence of instability, and other comfirmatory evidence will be cited later. Stability, however,is a relative term, and a substance which is stable under certain conditions

*Reprinted from the *Journal of the Washington Academy of Sciences*, Vol. xi, No. 13, July 19, 1921.

becomes unstable under others. The prime factors which determine external stability are temperature, pressure, and chemical evironment. For example, some compounds which are stable in anhydrous surroundings are decomposed in presence of water. Calcium carbonate, under ordinary conditions, is divided at high temperatures into carbon dioxide and lime, but heated in a steel bomb it not only remains undecomposed, but it may even be melted, to form upon cooling a crystalline marble. Examples like these might be multipled indefintely. As a rule stability diminishes with increasing temperature, but is favored by increased pressure. We may also assume that the more symmetrical an atom or compound is, the more stable it is likely to be. We are dealing now with compounds; but to the evolution of the elements the same general rules must apply.

Now, returning to our main problem, was the evolution of the elements a regular progression, such as might be represented by a smooth curve or a straight line; or was it irregular and quite independent of their order in the scale of atomic weights? To answer this question we must try to imagine what happened in the development of the larger masses, the nebulae and the stars. On this subject there is a plausible hypothesis which has been favored by many astronomers; namely that the nebula at first was relatively cool, that the temperature gradually rose to that of the hottest stars, and then regularly declined to the end of the series, the solid planet. A baseous mass contracting under the influence of gravitation, became warmer; at its centre where the pressure was greatest, the increasing condensation generated still higher degrees of temperature, until a luminous nucleus was formed. As condensation went on with increasing intensities of pressure, the temperature continued to rise until the heat generated by compression was less than that lost by radiation into space, when cooling began. Although this hypothesis, in its crude form, is not universally accepted, it nevertheless gives a fair conception of that part of the evidence with which we are concerned. The process of evolution from cool to hot and then to cool again is fairly outlined. The nucleus of the original nebula has its modern representative in the Sun.

In all the foregoing discussion it has been tacitly assumed that the nebula from which the solar system was developed was similar in all essential respects to the planetary nebulæ. The latter, as shown by their spectra, consist mainly of hydrogen, helium, and nebulium, with slight traces in some of them of carbon, nitrogen, and perhaps other elements. Nebulium is known only from its lines in the spectrum, and its atomic weight has been estimated by Fabry and Buisson as 2·7, placing it between hydrogen and helium. In any further study of relations between the atomic weights of the elements, nebulium must be taken into account, and perhaps also coronium, so called from its lines in the spectrum of the solar corona. From its position in the corona it is assumed to be lighter than hydrogen, and so would seem to be an even more primitive element. That possibility cannot be considered here; we must limit ourselves to the conditions actually seen in the nebulæ. No assumption is made as to the possible ancestry of the nebular elements. They are the visible beginnings.

Now it is easy to see that in the process of evolution from nebula to sun an orderly development of the elements could hardly have been possible. With changing temperatures, changing pressures, and changing environments, all the conditions required for a regular progression according to the order of the atomic weights were lacking. The order actually followed was that of relative stability. In the hotter stars only the most stable elements were formed, and naturally in the greatest abundance. Calcium (atomic weight 40) and iron (atomic weight 56) were among the earliest to appear, while the others, between helium (atomic weight 4) and iron, either came later or were developed at first in smaller quantities. As cooling went on more and more elements were generated, and in the Sun all the possible ones are presumably present. It is conceivable that elements of different stability may have been formed simultaneously, one in that part of the cooling mass where temperatures and pressures were highest, another further away from the centre under less rigorous conditions. This, however, is something which cannot be proved. If the three nebular elements were the raw material from which the other elements were built, their relative amounts must have been continually changing, and so as each new element appeared a new environment was established for all that followed. How far these changes may have affected the evolution of the elements it is impossible to say, but in the evolution of compounds similar conditions would be significant.

That some of the chemical elements are very abundant, and others comparatively scarce, is a familiar fact which bears directly upon the theory of evolution. Their relative abundance in known terrestial matter has been repeatedly computed, by several workers and by different methods. The results agree remarkably well, at least in the orders of magnitude as expressed in percentages. This order, when we combine the figures for the lithosphere, the ocean, and the atmosphere, is as follows. First, oxygen, then silicon, aluminium, iron, calcium, sodium, potassium, hydrogen, and titanium, and these ten elements form at least 98 per cent of the whole. Only 2 per cent remains for all the other elements, some 80 or more in number. (The details of the most recent computation of the relative abundance of the elements will appear in a joint paper by Dr. H. S. Washington and myself, which is in course of preparation).

For present purposes this estimate is obviously defective, for it covers hardly more than a thin film on the surface of the Earth and says nothing about the Earth's interior. This objection is easily met if we take three facts into consideration. The Earth behaves like a huge magnet, it resembles a huge meteorite, and its mean density is double that of the rocks forming its crust. From these facts, and other quite minor considerations which need not be discussed here, we may fairly assume that the interior of the Earth contains a large proportion of metallic iron, and the quantity of it needed to give with the crust the mean density of the globe can be calculated. This has been done by others, and it now appears that in the Earth as a whole, iron predominates,

oxygen and hydrogen fall to subordinate positions while the order of the other elements is little changed. Probably nickel would appear among the first ten elements, but such a change will not affect our argument. Ten or eleven elements, all below 59 in atomic weight, exceed in abundance all the others. They are structurally among the simplest elements, and therefore, presumably the most stable.

These conclusions may now be applied to the hypothesis of evolution. The total amount of matter in the original nebula was of course finite; a large part of it was absorbed in building the simpler and more stable elements, and only what remained was available for the development of all the others. This conclusion, I admit, is largely speculative, but it is a legitimate interpretation of evidence. It may be modified by future investigations, but it is not likely to be completely overthrown. It is possible that the relative abundance of the elements may be different in different parts of the solar system, but it is not probable that any of the higher elements can find a place among the first ten. The whole scheme of evolution may be figured diagrammatically as a series of waves in which the crests represent the elements, and the depressions the gap between them. In such a series the waves would reach their greatest height at iron, and then gradually flatten until the end where instability becomes most clearly evident.

Between the evolution of the elements and their degradation there is a sharp contrast. The two processes do not follow the same path. Uranium does not decay to thorium, that to radium, then to lead, and so on down the line. The same divergence is shown between the synthesis and decomposition of compounds. It would be easy, for example, to effect a direct synthesis of calcium carbonate from its elements; but to reverse the process without the intervention of other substances would be extremely difficult. To cite a different example, trinitrotoluene, the T.N.T. of recent warfare, is prepared by the action of nitric acid on toluene, a relatively slow operation. On the other hand, when T.N.T. decomposes it does so instantaneously, and the products are oxides of carbon, methane, water, and free nitrogen Something likes this happens in the decay of a radioactive element, but with a difference; uranium, thorium or radium decomposes atom by atom; T.N.T. flies to pieces in mass. The one process is slow, the other extremely rapid.

I have already specified the external conditions which determine the stability of an element or compound, but when we consider the atom by itself, internal conditions are more important. On the structure of atoms there is not as yet a complete agreement, and much remains to be done before the problem can be definitely solved. I cannot go into this subject in detail, but I may take it for granted that the conception of an atom as consisting of an electropositive nucleus attended by a few or many electrons of opposite sign, is well established. In such a structure symmetry would be conducive to stability, and any deficiency in that respect would be unfavorable. For a simple element, with few electrons, symmetry would be most easily attained, for a complex element with many electrons it would be more difficult. Furthermore, an atom to be stable must show an exact balance between the electropositive and electronegative charges. With a single ring or shell of electrons the force of attraction holding nucleus and electrons together should be strongest; with concentric rings of electrons the outer ones would be more loosely held, and the atomic structure should be weaker. This seems to be the case with uranium and its neighbours. Here the structures are the most complex, and the number of electrons greatest. In short, the conditions, internal and external, which determine stability are by no means simple, and some of them operate in opposite directions. They all agree, however, in favouring the evolution of the simpler elements and so render the fact of their greater abundance more intelligible.

When an atom of uranium decays, an *alpha* particle, which is an atom of helium, is first discharged, and with a very high velocity. By a succession of such discharges a series of products is generated, each one differing by four units in atomic weight from its predecessor. The atomic weight of helium is 4. Three of these products, omitting intermediate forms, are ionium, radium, and an "isotope" of lead. Ionium is isotopic with thorium, but not identical with it except in its purely chemical relations. The atomic weights are not the same. A similiar difference is found for the lead derived from radium, which differs from normal lead in having an atomic weight about a unit lower. The isotope of lead in the thorium series differs from the normal by about the same amount in the opposite direction. (For a discussion of the nature of isotopic lead see Clarke *Proc. Nat. Acad. Sci.*, 1918, iv., 181.) In short, the degradation path from uranium, and also that from thorium is approximately parallel to the path of evolution, but not identical with it. The short-lived products of radioactive decay might be described as the debris of exploding atoms. They do not appear in the ascending series of the elements.

For the elements below the radioactive group, that is, those of the lower aomic weight, some evidence of instability has recently been obtained Rutherford, by passing swiftly moving alpha rays through nitrogen, has observed a slight evolution of hydrogen, an indication that hydrogen is a constituent of the heavier and more complex element. Oxygen, treated in the same way, yields a product of different character, something which appears to have an atomic weight near 3. If, however, the value should be slightly lower, it would have a curious significance. Attention has already been called to the existence of nebulium, to which the atomic weight 2·7 bas been provisionally assigned. Tbis is very close to 2.666..., or $2^2/_3$ more precisely.

Now $2^2/_3 \times 6 = 16$, tbe atomic weight of oxygen, a relation which may possibly be experimentally verified. If the bombardment of oxygen were carried on for a long time it might yield a gas in which the spectral lines of nebulium could be detected; and if that were done it would be a step forward in the study of atoms. I offer the suggestion with some hesitation, but it seems to be worth considering. It affects a number of other elements of which the atomic weights are multiples of 16.

By a remarkable series of experiments F. W. Aston (*Science Progress*, 1920, xv., 212), has

obtained evidence which he regards as proof of the complexity of the atomic weights as determined by chemical methods. Powerful positive rays in a magnetic field were applied to a number of elements, which then gave what he terms their "mass spectra". These spectra show lines corresponding to whole number atomic weights, which represent, not the accepted values, but some higher and some lower. Chlorine gives two such lines, corresponding to atomic weights 35 and 37, and mercury gives at least six, ranging from 197 to 204. The last two figures, I may add, are near the atomic weights of gold and thallium, that of mercury being 200.6. These new lines, as interpreted by Aston, represent isotopes, and the accepted atomic weights are regarded as mere statistical averages. In other words the atomic weights known to chemistry relate to mixtures, and are not true constants.

I must here allow myself to indulge in a very obvious truism. Whenever new phenomena are discovered an attempt is made to interpret them, and to bring them into relations with other phenomena. But it does not always follow that the first interpretation is the only one possible, nor even that it the best. Now it seems to me conceivable, that the lines of Aston's mass spectra may really belong to decomposition products of the elements, produced by the disintegrating effect of the positive rays. This conclucion, I think, is more in harmony with chemical evidence than the one first proposed. It is, furthermore, sustained by the fact that the elements of high atomic weight seem to show as a rule more lines in their mass spectra than those low in the scale. The most complex elements should undergo the largest amount of disintegration. If the atomic weights as actually determined by the best modern methods are mere statistical averages of widely differing figures, then the elements must be regarded as variable mixtures, and uniformity could hardly be expected. This lack of uniformity would extend to all chemical compounds, which should vary in composition and also in physical properties; all chemical calculations would become inexact, and even the spectra of the elements would lose much of their significance. Chaos would rule instead of order.

In point of fact the evidence in favor of definiteness of atomic weight is much better than anything which has been adduced to the contrary. On that subject I could make a strong argument in support of my position; but I do not care to overload this paper with details. In discussing the evolution of the elements, and also their decay, I must take a pragmatic position and assume their integrity. Their evolution follows an upward path, with which the downward path of decomposition is approximately but not exactly parallel. The two paths, however, coalesce in the region of hydrogen, nebulium, and helium; and so the beginning and the end are the same. That hydrogen and helium are the chief constitutents of the elements as we know them is possible, as Harkins in a long series of interesting papers has attempted to show. I cannot accept all his conclusions as final, although he has at least discovered some interesting relations. Nebulium should not be left out of account.

On the mechanism of the process by which the elements were built up I have nothing definite to say. I can only ask questions. If a heavy atom, like that of gold or mercury, is formed from simpler atoms, how are the latter changed? What happens to their nuclei and their electrons? Is the structure of the carbon atom the same in graphite and in the diamond? Here the tetrahedral atom which plays so important a part in stereochemistry has to be considered. With compounds these problems become much more complicated, that is, if we try to explain them in terms of atomic structure. Among organic compounds we find isomers and polymers, and many of them contain a hundred or more atoms to the molecule. How are their electrons rearranged, and what are they doing? All these compounds, as I have already shown, are items in the general scheme of the evolution of matter, in which the question of atomic structure is fundamental. I have in this paper only touched the surface of a vast problem, but my imagination has never wandered far from evidence and reasonable analogies. Perhaps I have made suggestions which may lead others to the discovery of new truths.

A HIGH PRESSURE DUE TO ADSORPTION AND THE DENSITY AND VOLUME RELATIONS OF CHARCOAL.*

Papers on Surface Energy and Surface Forces.

By WILLIAM D. HARKINS and D. T. EWING.

I.—The Compression of Liquids by Charcoal.

While working on Problem 108 of the National Research Council in the year 1918, the writers discovered an interesting relationship, which is that the volume of different liquids adsorbed by the same charcoal increases in the same order as the percentage compression for a definite high pressure—such as twelve thousand atmospheres. Thus the charcoal seems to produce the same change in the volumes of liquids which penetrate it, as is given by a high pressure. In our preliminary report it was stated that while accurate calculations of the pressures which would have to be put upon these liquids to give the same percentage compressions, could not be made in the absence of data on an incompressible or very slightly compressible liquid, it seemed likely that the order of magnitude might be represented by twenty thousand atmospheres in excess of the internal pressure of the liquid. (It is obvious that the magnitude of the mean pressure decreases as the volume of liquid considered increases.) While there is nothing novel in the idea of the existence of such powerful adhesional forces at the surface of a solid, their experimental demonstration in such a direct way is somewhat remarkable, since the highest values for the internal pressures of liquids thus far experimentally demonstrated are 34 atmospheres with water at 24·4°, 39·5 atmospheres for ethyl alcohol at 22·5°, and 72 atmospheres for ether at 17·7°. (Donny, *Ann. chim.*

*Presented at the Philadelphia meeting of the American Chemical Society, September, 1919. This problem was suggested to the National Research Council by the senior author. The data for one charcoal with 11 liquids were published in February, 1920 (Harkins and Ewing, *Proc. Nat. Acad. Sciences*, 1920, vi., 49-56). The present paper is an abstract of a thesis presented to the University of Chicago in August, 1919, by D. T. Ewing, in partial fulfilment of the requirements for the degree of Doctor of Philosophy. Reprinted from *Journal of the American Chemical Society*, August, 1921.

TABLE I.—*Apparent Density and Pore-Volume Determinations for a Steam-Activated Coconut-Shell Gas-Mask Charcoal.* (Charcoal E 602; service time 47·2 minutes; $-\Delta v$=0·058 cc.). (Data at 25°).

1. Liquid.	2. Apparent density.	3. Pore volume 1 cc.	4. Per cent. compressed 12000 atmospheres.*	5. Surface tension, dynes per cm. γ.	6. Viscosity in absolute units. η.	7. $\frac{\gamma}{\eta}$.	8. b. × 10⁴
Mercury	0·865	—	—	57·0	—	—	—
Water	1·843	0·534	20·51	72·8	0·0101	7200	14
Propyl alcohol	1·960	0·559	22·03	23·7	0·0223	1062	76
Chloroform	1·992	0·566	—	27·13	0·0057	4760	45
Benzene	2·008	0·568	—	28·88	0·0064	4510	54
p-Xylene	2·018	0·571	—	28·33	0·0064	4430	81
Petroleum ether	2·042	0·579	—	—	—	—	—
Carbon disulphide	2·057	0·580	25·75	31·38	0·0037	8480	34
Acetone	2·112	0·590	27·0	23·50	0·0033	7120	44
Ether	2·120	0·592	30·0	17·1	0·0024	7125	30
Pentane	2·129	0·593	More than ether	About 15	0·0024	6200	65

*The solubility of gases in these liquids increases in *general* with the percentage of compression or the compressibility, but the order is not exactly the same. The values for the density and for the pore volume listed in this table are calculated on the basis of the incorrect assumption that the liquids are incompressible. The same values would be obtained if the liquids are compressible but are not compressed. The eighth column gives the values of b of van der Waals' equation.

TABLE II.—*Apparent Densities of Eight Charcoals in Water, Mercury, and Various Organic Liquids.*

Charcoal.	Liquid.	Apparent density.	Mean apparent density.	Volume of carbon in 1 cc. charcoal.	Volume of pores in 1 cc. of charcoal.
Charcoal A	Hg	0·843	—	—	—
(Steam activated, coconut shell-charcoal;	Hg	0·841	0·842	—	—
impregnated with copper; service time=42·9	H_2O	2·112	—	—	—
minutes; $-\Delta v$=0·052 cc.).	H_2O	2·112	2·112	0·390	0·601
	C_6H_6	2·291	—	—	—
	C_6H_6	2·298	2·295	0·366	0·643
	Ether	2·432	—	—	—
	Ether	2·422	2·426	0·347	0·653
Active carbon No. 4	Hg	0·705	—	—	—
(From anthracite coal and pitch; service time	Hg	0·713	0·709	—	—
=40·9 minutes; $-\Delta v$=0·067.).	H_2O	1·807	—	—	—
	H_2O	1·809	1·808	0·392	0·608
	Ether	2·186	—	—	—
	Ether	2·172	2·177	0·325	0·675
Charcoal No. 1	Hg	0·869	0·869	—	—
(Air activated, coconut shell-charcoal;	H_2O	1·863	1·863	0·467	0·533
service time 32 minutes; $-\Delta v$=0·053 cc.).	C_6H_6	2·014	2·014	0·432	0·568
	Pet. Eth.	2·042	2·042	0·421	0·579
	Ether	2·094	2·094	0·414	0·586
E621	Hg	0·989	—	—	—
(Air-activated, coconut shell-charcoal; service	Hg	0·998	0·995	—	—
time =27 minutes; $-\Delta v$=0·051).	H_2O	1·832	—	—	—
	H_2O	1·838	1·835	0·542	0·458
	Ether	2·023	—	—	—
	Ether	2·020	2·026	0·491	0·509
Active carbon No. 1	Hg	1·177	—	—	—
(From anthracite coal and pitch; service time	Hg	1·172	1·175	—	—
=19 minutes; $-\Delta v$=0·043 cc.).	H_2O	1·936	—	—	—
	H_2O	1·932	1·934	0·609	0·391
	Ether	2·076	—	—	—
	Ether	2·074	2·075	0·566	0·434
Active carbon No. 3	Hg	1·488	—	—	—
(From anthracite coal alone; service time=	Hg	1·492	1·490	—	—
11 minutes; $-\Delta v$=0·018 cc.).	H_2O	1·880	—	—	—
	H_2O	1·872	1·876	0·799	0·201
	Ether	1·911	—	—	—
	Ether	1·902	1·906	0·781	0·219
Laboratory charcoal	Hg	0·521	0·521	—	—
(From beechwood; service time=0·0 minutes;	H_2O	1·644	1·644	0·317	0·683
$-\Delta v$=0·004 cc.).	Ether	1·665	4·665	0·313	0·687
Cedar wood	Hg	0·817	—	—	—
(Service time=0·0 minutes; $-\Delta v$=0·008 cc.).	Hg	0·813	0·815	—	—
	H_2O	1·497	—	—	—
	H_2O	1·502	1·499	0·544	0·456
	Ether	1·504	1·504	0·536	0·464

phys., 1846, xvi., 167; Berthelot, *ibid.*, [3], 1850, xxx., 232; Moser, *Ann. phys.*, [2], 1877, clx., 138; Helmholtz, *Ges. Abh.*, 1887, iii., 264; Worthington, *Phil. Trans.*, [A], 1892, clxxxiii., 355; Meyer, "Zur Kenntnis des negativen Druckes in Flussigkeiten," Halle, 1911. The heat of adsorption was discovered as a phenomenon by Pouillet nearly one hundred years ago (*Gilb. Ann.*, 1823, lxxiii., 356). The hypothesis that the high heat of adsorption indicates that it may be convenient to look upon adsorbed material as in a compressed state, is also very old. It is discussed in Freundlich's "Kapillarchemie," (*Leipzig, 1909, p. 111*) However, the work of the present writer gives the first direct experimental demonstration of this compression, and shows that the magnitude of the effect is much greater than has usually been supposed).

Our hypothesis that the compression of the liquid is due to a pressure of this order of magnitude at the interface liquid-charcoal, is supported by the very interesting work of Lamb and Coolidge (*Jour. Amer. Chem. Soc.*, 1920, xlii., 1146-70), who approach the subject from an entirely different experimental standpoint. They find that the net heats of adsorption are closely proportional to the heats of compression under high pressure, which "indicates that the liquids are all attracted by the charcoal with substantially the same force, and that the net heat of adsorption is merely heat of compression. The absolute value of this attractive force appears to be about 37,000 atmospheres when 1 cc. of liquid is adsorbed on 10 grms. of charcoal." Still another paper, also published later than our own, comes to the conclusion that the volume of a liquid in charcoal is different from the volume of the same mass of the same liquid in bulk. (A. M. Williams, *Proc. Roy. Soc.*, December, 1920, xcviii.A., 223-34. The writer has not been able to consult this paper, since the number has failed to reach any of the Chicago libraries).

In March, 1920, Cude and Hulett (*Jour. Amer. Chem. Soc.*, 1920, xlii., 391-401; their results on benzene are affected by some factor which we have been able to duplicate) published data on the volume and density relations of one charcoal as obtained with four different liquids. It happened that at the time our preliminary paper giving data on eleven different liquids had been published, and we were somewhat disturbed to find that the agreement between the two sets of data was not as perfect as might have been desired, though the only discrepancy was for the single liquid benzene. However, on this account the publication of the present paper has been delayed for considerably more than a year. During this time Mr. C. E. Monroe has repeated a number of the determinations, and has extended the investigation to other liquids for which the compressibilities have been determined by Bridgman. His results will be published in a separate paper, but it may be stated that they agree almost exactly with those of the present and also of the preliminary publicaion.

In the experiments presented here the charcoal was outgassed by the use of a mercury condensation pump with a large throat and connecting tube (25 mm. in diameter), but it was found necessary to constrict the tubes near the charcoal bulb to 1 cm. The apparatus first used was similar to that described by Lemon (*Phys. Rev.*, 1919, xiv., 283) since we had two sets of this apparatus for work on the speed of adsorption of various poison gases. However, such an elaborate apparatus is unnecessary for the work on liquids, and a system without stopcocks was found to be better for this purpose. The outgassing was first conducted at low temperatures, with a gradual increase to 600°. The tubes of charcoal were kept at the latter temperature from two to three days, or until the pressure registered by the McLeod gauge had fallen to 0·0001 mm. and had remained as low as this for at least six hours. This pressure was determined while the pump was still running, but the tubes of charcoal were connected to the main vacuum line (1·5 cm. in diameter) between the gauge and the pump. The neck of the bulb, which usually contained about 10 grms. of charcoal, was then sealed off to a point while the bulb was still kept hot in the electric furnace. The bulb was cooled, the point dipped under the surface of the hot liquid, and broken off, so as to allow the liquid to rise into the tube. The tube was weighed at intervals, being kept in a thermostat at 20·00°, except during the periods it was kept in the balance. The surface of the liquid was so adjusted in the thermostat that the lower part of the meniscus was exactly at a fine circular graduation made on the neck of the tube where it had been constricted to a capillary. After the drift had ceased, the final data as recorded, were obtained. The character of this drift has been treated by Cude and Hulett, and will be considered by Mr. Monroe, so only the final density data will be presented here.

II.—Apparent Density and Volume Relations of Charcoal.

The most closely agreeing data were obtained by the use of a steam activated, coconut-shell, gas-mask charcoal E 602, which gave a service time of 47·2 minutes by the accelerated chloropicrin test. On account of the close agreement of the three or more density determinations with each liquid, in general to ±0·001, only the average values will be included in Table I., which gives the results for this charcoal. The density listed in col. 2, and the pore volume given in col. 3, are not the real, but only the apparent values, calculated on the basis that the liquids are incompressible, or what amounts to the same thing in this case, that the liquids are not attracted by the charcoal sufficiently to cause any compression. Since apparently this kind of assumption is not justified, the true density and pore volume can be calculated only when the correct interpretation of the cause of the considerable variation shown in the Table, is obtained.

In order to understand the volume and density relations upon which the adsorptive properties of charcoal depend, it is important to obtain an idea of the structural relations of coconut charcoal, in so far as the latter can be revealed by the use of the microscope. The writers have about 60 microphotographs, with magnifications as high as 2000, prepared by Dr. Rheinhardt Thiessen of the U.S. Bureau of Mines, and these have been used in the present study of the pore volume relations. Unfortunately none of these can be presented here, but reference may be made to three microphotographs reproduced in an earlier paper by Lamb,

Wilson, and Chaney (*J. Ind. Eng. Chem.*, 1919, xi., 420-38), which do not, however, represent all of the types of structure found. A reference to their Figs. 7 and 8 (pp. 428 and 429) of their paper will show that the lumps of charcoal contain many pores which are visible at a magnification of 732 diameters. Those visible at a magnification of 2000 may be called capillaries or macropores. The walls of carbon, which are represented by the light portions of the figure, are undoubtedly very porous, and contain an enormous number of "micropores" which are ultramicroscopic. A study of the photographs shows that the mean diameter of the macropores is about 12 microns (this diameter is dependent upon the methods of production of the charcoal). The micropores may be defined arbitrarily as those whose diameters are less than 10^{-5} cm. (less than 100 millimicrons), though vapour-pressure measurements indicate, in so far as they are of any value for this purpose, that they are mostly of the order of 10^{-6} cm. or less, in diameter.

Since mercury penetrates neither the capillaries nor the micropores, the density given in Table I. and II., with this liquid used to fill the "voids" between the lumps of charcoal, is that of the lumps themselves, walls, micropores, and capillaries included, or what is known as the lump or "block density." It will be seen that this density is close to 0·85 for two of the highly activated coconut-shell charcoals, but is considerably higher for the slightly activated charcoal E621, for which the value is practically 1·000. The density of the cedar wood charcoal, 0·815, is very nearly the same, yet this specimen shows an almost zero service time, while beech wood charcoal, also a very poor adsorbent, has a block density of only 0·521. The active carbon 4, with a moderately high service time of 40·9 minutes, has a moderately low density (0·709), and the much less active No. 1, also made from anthracite coal and pitch, has a much higher density (1·175), while the still less active carbon No. 3, with the low service time of 11 minutes, has a very high density (1·490) (all of these data refer to the lump density).

(To be continued).

SOME REFLECTIONS ON LEAD ALLOYS.

M. Leon Guillet observes that he made a profound study of lead-thallium alloys, and that the formation of the diagram revealed the following particulars.

The liquidus, and consequently the solidus, present a maximum corresponding to the combination Pb_2Tl, which enters into solution in lead.

Now hitherto the two following facts have been noted :—

1. A combination is hard and fragile.
2. When two metals enter into solution they are both malleable or both not so.

Lead and thallium being soft metals, and the combination entering into solution, it is evident that one of these two general principles must fail in the case in question.

Experience has demonstrated that it is the first which is wanting. There is a minimum hardness in the combination. The diameters of the impressions made in Brinell ball tests of pure and combined metals were :—

Pb : $d=3·95$. Pb_2Tl : $d=4·30$. Tl : $d=4·05$.

A curious detail must be noted. It being very difficult to polish lead-thallium alloys, they were melted in crucibles with a polished aluminium-bronze bottom plate. If we add these results to the observations made by M. Nicolardot, viz., that these two metals do not harden at an ordinary temperature but at a very low one, a proof that their annealing temperature is below the ordinary one, we can see that there is a very interesting subject for study.—*Comptes Rendus*, October 15.

INDIAN INDUSTRIES.

The first volume of the *Journal of Indian Industries and Labour** is now complete with the issue of part 4.

To this part of the Journal, Mr. B. Abdy Collins, Director of Industries, Bihar and Orissa, has contributed an interesting review of the industrial situation in Chota Nagpur and Orissa, touching on the natural resources of the tract, which "contains nearly all the coal and most of the iron ore hitherto located in India, besides other minerals such as copper, chromite, mica, limestone, manganese, monazite, graphite, bauxite, china clay and fire clay". The article includes a survey of the great metallurgical works already established, the schemes in hand for their development, and for the institution of new subsidiary industries. The author's views on the problems of the coal trade and railway transport will be of general interest, since the difficulties with which the industries of his province are faced in this respect are by no means confined to Bihar and Orissa.

Mr. Kale's article on the economic aspect of the boycott of foreign cloth provides much food for reflection. A stalwart apostle of the *swadeshi* principle, yet he calls attention to the danger of diverting labour from mills and factories to hand-spinning and hand-weaving. The argument for the other side is expounded by Mr. K. Sanjiva Rao, Textile Expert to the Government of Bihar and Orissa, whose note on hand-loom weaving in India deprecates both on economic and on social grounds the strangling of that industry by factory development, and propounds a scheme for its revival even in the teeth of the large scale power-loom mills.

Much has been said and written in the past about the lack of manual skill displayed by the average Indian craftsman, and the crying need for providing facilities for his technical training. Those interested in the subject will do well to read Mr. Cove's article "Technical Training", in which he cites a number of trades, which are characterized by bad workmanship, due to lack of training. His criticisms are pungent, and it is possible that some of his cases may be overstated, but few will challenge his conclusions; coming moreover from a practical man who for many years has been in intimate contact with the class of labour which is the subject of his article, his remarks should no go unheeded.

Miss Broughton's article on the problem of

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industrial fatigue in India deserves the attention of all who are in any degree responsible for the efficiency of factory administration and the well-being of factory labour. Her account of the effect on output caused by a shortening of the working hours in a well-known English factory will no longer come as a surprise to those who have studied the physiological side of labour; but many will be interested to hear how by a study of the movements involved in certain work, by training the workers, improving appliances and exacting shorter hours of work with higher wages, an iron foundry increased its weekly output from 3,000 plugs (the estimated capacity of the plant) to 20,000—while another firm, with larger plant, found it difficult to maintain an output of 5,000 plugs. A striking commentary on the practical effect of good ventilation in factories is to be found in the graph which accompanies Miss Broughton's article.

To those interested in tanstuffs, particularly in the exploration of new tanning materials Mr. Das's article "Mangrove swamps in the Sunderbans Forest Division, a valuable source of tanstuffs" will commend itself. The writer recapitulates the results of Mr. Pilgrim's investigation into the tanning qualities of various mangroves of these tracts, and gives in tabular form an account of the behaviour of the tanstuffs when utilized experimentally at the Calcutta Tanning Research Institute.

"The Bengal (Smoke) Commission had been so successful that in less than three years it had diminished the dense smoke from (Calcutta) factory chimneys by over 80 per cent." This statement, made in the House of Lords in 1914, speaks for the efficiency of the measures taken to reduce the smoke nuisance in Calcutta. Mr. Robson has contributed an article to the Journal in which he outlines the way in which the Smoke Commission grappled with the smoke nusiance in Calcutta; his remarks on the reduction of fuel-costs due to improved types of furnaces will repay reading. The general public too are interested in that smoke reduction and control means a considerable saving in the laundry bill.

Mr. Barbour, of the Titaghur Paper Mills, has contributed an article on modern paper-making, which will be read with interest by persons interested in forest exploitation and by paper manufacturers generally. He refers to the vicissitudes of the industry in the past, the difficulties that beset it at the present and the steps which he advocates to set it on a firm and permanent basis for the future.

The fourth part of the Journal contains also among other things a summary in tabular form of industrial disputes during the third quarter of the current year, summaries of "industrial intelligence" contributed by each province, miscellaneous notes (which include a note on briquetting experiments with Indian charcoal undertaken in the United States of America) and an abstract of the Bulletins of Indian Industries and Labour published during the year.

Since the issue ofthe third part of the Journal the following bulletins have been published:—

No. 16.—Notes on Indian Piece Goods Trade.

No. 17.—The Genoa Labour Conference (official correspondence).

No. 18.—Proceedings of the third Conference of Departments of Industries held in Simla on the 23rd to 26th May, 1921.

HIGH TAXATION.

The F.B.I. and the Chancellor of the Exchequer.

Sir,—I enclose copy of a letter which has been forwarded to-day to Sir Robert by Col. O. C. Armstrong, the President of the Federation of British Industries.

The mass of evidence collected from the chief industrial centres of England, Scotland and Wales points to the fact that the present burden of taxation is crippling the efforts of manufacturers to recover and extend their foreign markets, and is stifling the possibility of a trade revival, which is so urgent if an alleviation of the present unemployment position is to be achieved.

The Federation feel it their duty to warn the Government of the certain consequences that will result if taxation on industry is maintained at its present high level, and is pressing the Chancellor of the Exchequer for a reduction of the Income Tax and the abolition of the Corporation Profits Tax.—I am, Sir, yours faithfully,

S. D. Benbow Hebbert,
Director's Department.

To The Rt. Hon. Sir Robert S. Horne, C.B.E., K.C., M.P.

Sir,—The Federation of British Industries has just concluded its annual investigation into the effects of the past year's taxation, and the views of Industry as to the future. In the course of this investigation general meetings were held at Sheffield, Nottingham, Bristol, Swansea, Leicester Dundee, Edinburgh, Glasgow, Newcastle, Northampton, Birmingham, Liverpool, Manchester, Bradford and Leeds, at which unanimous resolutions in the most emphatic terms were passed demanding the abolition of the Corporation Profits Tax and an immediate and substantial reduction in the rate of the Income Tax.

The fall of prices and values during the past year has been unprecedented both in extent and rapidity, with the result that the effects of taxation have been felt by industry with peculiar severity.

The capital resources of many industries have already been strained to the utmost by the need for larger working capital to meet post war conditions of production, and the operations of Excess Profits Duty have prevented the accumulation of reserves sufficient to meet so serious a crisis, while enormous local taxation and the Corporation Profits Tax still further depleted the available resources of Industry during the year.

Under these circumstances the burden of Income Tax at a high rate, assessed upon the average of the three years which included the greatest industrial boom in history, has assumed crushing proportions, and many firms have already been driven to impair their future productive capacity by paying the current years' taxation out of

capital or by loan.

It is fully realised that high taxation has only been one among the many contributory causes of the present depression. It is, however, the only one of these causes which can be mitigated promptly by the independent action of His Majesty's Government.

The chaotic condition of the exchanges, the adverse financial and political conditions prevailing in many of our principal markets and the general disorganisation of the world's commercial system are all susceptible of remedy, but the remedy will take time, and most of these factors will still be in operation to restrict trade and hamper production during the forthcoming year.

Under these circumstances it was the unanimous opinion of the District General Meetings that any attempt to maintain taxation at its present level during the forthcoming year must at best seriously retard any industrial recovery, and at the worst may involve a permanent diminution in the productive capacity of the country.

The evidence brought forward at these meetings by speakers from all industries showed that the present rate of taxation is stifling initiative, postponing development, and crippling the efforts of manufacturers to recover and extend the foreign markets which are now of such vital importance to the welfare of the country.

The Federation warned the Government last year that Industry anticipated the most serious results from a continuance of high taxation. The meetings of this year afford overwhelming evidence that this warning was fully justified and have disclosed the gravest alarm as to the future if the present level of taxation is maintained.

The Federation desire to urge you most earnestly to consider the grave danger to the economic position of the country which will be involved by disregarding this warning a second time and to realise that the question is not now one of mere hardship or even of possible disaster to individual firms, but whether the whole industrial system of the country can possibly withstand any prolongation of the strain to which it has been subjected.

They feel that it is outside their province to suggest to you the means by which a sufficient reduction of taxation could be rendered possible. They wish, however, to place on record their conviction that under the present circumstances Government activities must be reduced substantially below their pre-war level. They are fully aware that such a reduction will involve the sacrifice of many activities admirable in themselves and valuable to the country, but it is in their opinion better to face these sacrifices now when so doing may avert still more serious consequences, than to postpone them to a future date when the ruin of Industry and a dwindling revenue will force them upon the country.

They trust that the Committee which has been sitting under the Chairmanship of Sir Eric Geddes will be able to suggest to you economies sufficient to enable the necessary reduction in taxation to be effected immediately, since they are convinced that such a reduction would have a psychological effect both at home and abroad which would be of the utmost value at the present moment in restoring confidence and enterprise, and indeed might of itself alone provide a sufficient stimulus to start the revival of trade which is so urgently needed.

They are firmly convinced that a substantial reduction of taxation would in a short time so increase the general volume of trade as to yield a larger revenue than could possibly be hoped from its maintenance at a higher level.

The Federation feel that they would fail in their duty as the responsible and representative organisation of Industry in this country if they did not use their utmost endeavours to impress upon you and upon His Majesty's Government their firm conviction that any step, however bold, is preferable to the certain consequences of the maintenance of taxation at its present level.—I am, Sir, your obedient servant,

O. C. ARMSTRONG, President.

PROCEEDINGS OF SOCIETIES.

SOCIETY OF GLASS TECHNOLOGY.

THE Forty-Eighth General Meeting of the Society of Glass Technology was held in University College, London, on Wednesday, December 4, 1921, at 2.45 p.m., the President, Dr. Morris W. Travers, F.R.S., in the Chair.

During the forenoon, by the courtesy of the Directors, a party of some 60 members of the Society paid a visit to the Charlton works of Messrs. United Glass Bottle Manufacturers, Ltd., lunch being also very kindly provided. Apart from the oil-fired furnaces, chief interest centred round the 10-arm Owen's automatic bottle-making machines, some of which were turning out nearly 60 bottles per minute.

At the afternoon meeting, the members expressed their cordial appreciation of the facilities accorded them in a hearty vote of thanks to Mr. G. E. Alexander, O.B.E., and his co-directors on the Board of Messrs. United Glass Bottle Manufacturers, Ltd.

The following papers were then given:—

"*A Suggested Method of Investigating the Viscosity of Glass.*" By I. MASSON, N. F. GILBERT, and H. BUCKLEY.

In presenting this paper, Mr. Gilbert observed that few methods were suitable. The one they had used was that of dropping a metal sphere, usually a ball-bearing, into a viscous substance such as syrup, and applying a modified form of Stokes' law. Ocular measurement of the rate of fall of the metal sphere agreed fairly well with the X-ray measurement where the shadow of the sphere was projected on to a photographic plate. In the case of molten glass, alundum crucibles had been found quite satisfactory, with platinum or large nickel balls. Lantern slides were shown in illustrating the method.

DR. MASSON having also spoken, the PRESIDENT Mr. F. Twyman, and V. H. STOTT, took part in the discussion that followed.

"*Note on Pipettes.*" By VERNEY STOTT, B.A. (National Physical Laboratory).

This paper was illustrated by lantern slides, the conclusion arrived at being: (*a*) Pipettes should

be adjusted for a particular delivery time, and when testing pipettes it is important to record both the delivery time and capacity; (*b*) the delivery time should be within certain limits as pipettes are unsatisfactory if the delivery time is too short, and also if it is too long; (*c*) a definite period should be allowed for drainage when graduating, testing, and using pipettes.

The PRESIDENT and Messrs. TOWERS and A. STEVENSON contributed to the discussion that followed.

"*The Annealing of Glassware and Annealing without Pyrometers.*" By F. TWYMAN.

This paper, which was illustrated by lantern slides, experiments, and demonstrations, gave an account of some work done since the reading of a paper on "Annealing", before the Society in February, 1917. It was based on the assumption that so far as the practical annealing of glassware was concerned, the problem was simply one of the release of strain in a highly viscous liquid. There were two difficulties involved in determining the annealing temperature of a glass from its viscosity. The first is fundamental. If E is the modulus of elasticity, T the time of relaxation, then the viscosity is E×T. But the time of relation cannot be determined from the viscosity unless at the same time the modulus of elasticity be known, and data are not available for the modulus of elasticity of glasses at temperatures within the annealing range. At the same time, glasses do not enormously vary their moduli of elasticity as the temperature is raised, and a very big change of modulus of elasticity would be necessary to cause any important difference of annealing temperature. The second objection is of a practical nature. In determinations of annealing temperatures which are obtained by means of measurement of viscosity, one requires to measure the temperature at which the viscosity of the given glass has an observed value. This requires a pyrometer, and a small easily controllable furnace.

The method proposed removes both these objections and is based on Maxwell's expression for the removal of strain in viscous solids. If we define the desired state of annealing by saying that we require the stresses originally present to be reduced in a particular proportion we may write as original stress F_0 and we then have the proportion of stress left in the glass at the end of time *t*.

$$\frac{F}{F_0} = e - \frac{t}{T}$$

T being the time of relaxation.

If now we can observe, during the process of annealing, the proportion of stress left in the glass (compared with that present before the process commenced) from time to time, we can stop the process when that proportion has arrived at a sufficiently small fraction, say 1/10 or 1/20, and nothing further is necessary. In stating the problem thus we no longer rely on Maxwell's law, but merely assume that $\frac{F}{F_0} = f(t)$ when $f(t)$ does not depend on the stress. Now, although we cannot conveniently observe the stress F on the objects themselves during annealing, we can do something nearly as good. A piece of the glass required to be annealed (which piece may be of any shape and size so long as it is possible to deform it elastically by a comfortably perceptible amount) is introduced into the furnace among the articles to be annealed. It is elastically strained by a definite amount, sufficient stress being brought to bear to deform it to that extent, and is in this way brought to an artificially unannealed state. Periodically the stress is removed, and it is allowed to spring back if it will to its original shape. As the temperature of furnace is raised, a time will come when the test piece does not spring back entirely, and from a record of the time during which the piece has been kept strained at a particular temperature and the extent to which it recovers its original position, it would be possible if desired, to calculate the time of relaxation at the temperature. But for practical purposes that is not necessary, for if it springs back on release by one-half its originally strained amount, we know that it has been half annealed; if to one-tenth it is 90 per cent annealed, and so on, and this time is quite independent of whether the lehr has been kept at constant temperature during the annealing or not. And if the test piece deliberately strained is thus annealed, then the other objects which have passed through the same temperature and were originally strained by want of annealing, will become annealed simultaneously to the same degree.

Several forms of apparatus derived from these considerations were described and demonstrated.

A discussion followed in which there took part the President, Prof. E. G. Coker, Messrs. E. A. Coad-Pryor, V. H. Stott, and R. L. Frink.

CORRESPONDENCE.

LINE ENTITIES AND LINE DOMAINS.

To the Editor of the Chemical News.

SIR,—In my article in last week's issue I omitted to mention that in the equation $A-B=h\nu$, the letters A and B here stand for the energies of the "stationary" states, corresponding to the respective radii. They should be designated A_1 and B_1 to distinguish these values from the radii.

Moreover, in view of the statement I made about the velocity of the planet Mercury, I should explain that the advance of the perihelion is not due entirely to a change in velocity. Eddington in his book "Time, Space and Matter", remarks on this point as follows: "It had already been recognised that the change of mass with velocity may cause an advance of perihelion; but owing to the ambiguity of Newton's law of gravitation the discussion was unsatisfactory. It was, however, clear that the effect was too small to account for the motion of perihelion being $\frac{1}{2}\ v^2/c^2$, or at most v^2/c^2. Einstein's theory is the only one which gives the full amount $3\ v^2/c^2$." *c* is the velocity of light and *v* the velocity of the planet. "It was suggested by Lodge that this variation of mass with velocity might account for the whole motion of the orbit of Mercury, if account were taken of the sun's unknown absolute motion through the aether," but Eddington has pointed out that if this were so the other planets would

give observable effects, and these do not exist. In Einstein's theory the sun's gravitational field has to be taken specially into account, as well as the change in velocity.—I am, &c.,

F. H. Loring.

NOTES.

Boiler Water and Purification.—The scale-producing substances are chiefly calcium and magnesium bicarbonates and calcium sulphate. Three periods can be distinguished in the formation of scale, viz: (1) precipitation of calcium carbonate; (2) that of magnesium carbonate (104°-115° C.); (3) precipitation of calcium sulphate at 140° C. When there is silica in the water, there is a deposit after the commencement of boiling, of calcium silicate in form of a hard layer similar to porcelain and highly insulating even when very thin. All methods of chemical purification remove a greater or less quantity of scale-producing matter, but not the gases. On the other hand, water purified by chemical agents has usually too great a percentage of alkalinity, and this causes foam, involving frequent purging. Thus it is necessary to free the water from gas, *e.g.*, by boiling. Water thus treated should be run directly into the boiler. If stored in tanks it should be kept out of contact with the atmosphere so as not to absorb oxygen or carbonic acid.—*Bull. Soc. Chimique*, October 20, 1921.

A New Process for Estimation of Silica.—Everyone is acquainted with the difficulties in quantitative analysis of silica, in presence of a *great excess of alkaline salts.* These difficulties were very carefully studied by Hildebrand, who demonstrated that in spite of two insolubilisations in a hydrochloric medium, all the silica was not obtained, and that the non-precipitate silica was not found quantitatively with the alumina in analysis. Substituting $HClSO_4H_2$ he attained more precise results. It was with a view to finding a less long process giving better results that M. Travers studied a method. He demonstrated that it enables a precise estimate of silica to be made, in presence both of fluorine and alumina, whereas Berzelius' method gives inferior results. This method is particularly interesting for in research for SiO_2 in presence of fluorine. This separation is one of the most difficult known. The only methods described are based upon that of Berzelius, more or less modified. Finally, all the silica is obtained in one precipitation.—*Comptes Rendus*, October 24.

Temperature of Drying Samples.—Some minerals and residues from various manufactures disengage even after complete dessication at 100° C., water in some cases and an oily volatile matter in others, when they are heated to 105°-110° C. Consequently different results are given when question of fixing the degree of humidity for the nett dry weight in the invoice, or the percentage of merchantable metal; *in dry matter*, say contracts, but at what temperature? In some instances the percentages vary by several units, according to the temperature of dessication (water stove at 100° C. or hot air, 105°-110° C.). It cannot be denied that samples should be dried at the same temperature both for acceptance (nett dry weight) and analysis. It is to be desired that, by a generally admitted stipulation, a uniform temperature of 100° C. will be recognised, or in the absence of such agreement, that the temperature at which humidity has been estimated for delivery will be marked on the samples for analyses, thus avoiding disputes between the chemists of sellers and buyers or arbitrators.—*Annales de Chimie Analytique*, August 15, 1921.

Sugar Works Ammonia.—The Pithiviers Sugar Works (Soc. Sucrière de Pithiviers) intends to manufacture ammonia, for which purpose three processes have been acquired. The first and simplest consists in the recovery of nitrogen from beet which passes into the molasses and vinasse. Thus pure ammonia, acetic acid, and benzoic aldehyde are produced. Were all the molasses manufactured in France thus treated, 17,000 tons of sulphate of ammonia would be obtained. The other processes purchased by the company are synthetic. One is based upon the fixation of atmospheric nitrogen and subsequent decomposition of the compounds. The second is an electric synthetic process yet being tested in the laboratory, but in a sufficiently advanced stage to be soon applied on an industrial scale. The first and second of these processes are shortly to be applied in this sugar works.—*L'Engrais*, Nov. 15.

Alsace.—It is estimated that in 1922 the mines will produce 10,000 metric tons of potassium chloride, considerable quantities of which will be available for export.—*L'Engrais*, November 15.

Norway.—The shares of the Notodden Nitrogen Co. have risen in consequence of the Oppau catastrophe, a formidable riva lbeing thus removed. The Notodden and Rjnkan Works will now he enlarged and the workmen recently discharged given employment.—*L'Engrais.*

Echo of Coal Stoppage.—The disastrous policy of withdrawing the safety men from the mines during the coal stoppage of last Spring is in no small degree responsible for the high figure of unemployment among the workers of the mining industry. This is exemplified in the case of Hucknall No. 2 colliery, which has only just reopened since closing down on March 31 last. Serious damage to the shaft resulted fom the total abandonment of the mine. The management spared no effort to expedite the repairs necessary for re-opening the property, but this has proved a long and difficult business. There has been considerable distress among the workers formerly employed. They have now been given the opportunity of signing on to re-start work.

£10,000,000 Saved on Coal Bill.—The Glasgow Chamber of Commerce, on December 12, in adopting a resolution demanding a reduction in Scottish railway rates, stated that the railway companies' expenditure had been decreased by £10,000,000 per annum owing to the reduced price of locomotive coal. A reduction in railway rates was essential for a revival of industry.

South African Paper-Making Project.—A company is being formed in Natal to undertake the manufacture of wrapping paper from wattle wood and spent bark from the wattle extract mills, states the *South African Journal of Industries*,

A process is reported to have been discovered by which excellent wrapping paper can be made from these materials. It is proposed to make news print from wattle bark combined with tambuki grass later on, and also cardboard for the manufacture of fruit and egg boxes from spent bark.

WATER POWER RESOURCES IN SCOTLAND.—The broad results of the Committee's enquiries are as follows: They find that in Scotland, especially the Highlands, the natural conditions are such as to facilitate the production of power. In this area the bulk of the larger water-powers of the British Isles is situated, and although it is remote from the present industrial centres, no part of it is far from the sea or the Caledonian Canal. The larger water-powers of Wales are situated in the north-western portion of the Principality. As compared with the Scottish water-power resources, the cost of developing the larger of the Welsh resources as separate schemes would usually be high. While there are several schemes worthy of careful consideration on an individual basis, it would be desirable to consider the development of a number of the less favourable as adjuncts to other more favourable schemes. As in the case of Scotland, there are numerous sites capable of developing small blocks of power. As regards England, generally, the main sources of water-power are the small falls on rivers. The Committee consider, however, that the aggregate output from these sources could be materially augmented by installing modern plant, replanning existing sites, and generally improving the water-courses. In Ireland a certain amount of power can be developed from high level lakes in the mountainous areas, but the main sources of water power are to be found in the rivers. It is generally considered that the utilisation of the water powers of the United Kingdom would tend to relieve the increasing congestion of our large centres of population, and in the case of the Highlands of Scotland would assist materially in improving the present low standard of comfort of the inhabitants of that area, and thus arresting the abnormal emigration from it. The potential water power of the schemes before the Committee (not the total available) was estimated at 194,965 kilowatts (continuous) in Scotland, 35,900 kilowatts in Wales, and 20,440 kilowatts in England. The Irish Sub-Committee made an estimate of 280,000 kilowatts (continuous) as the total available potential water-power in Ireland. It was further estimated for Great Britain that probably 210,000 kilowatts (continuous) could be developed at an economic rate. This was given as the equivalent in energy of nearly three million tons of coal per annum burnt in steam plants.—*Board of Trade Journal.*

TOKIO PEACE EXHIBITION.—The Department of Overseas Trade is in receipt of information regarding the forthcoming Peace Exhibition which is to be held there from March 10 to July 31, 1922. It would appear that all the space available for foreign exhibits has been over applied for. Messrs. Arthur Buckney & Co., of Tokio, have, however, secured a special site for the erection of a British Pavilion, and intending exhibitors can obtain space therein on application to the London office of the firm at 40, Westminster Palace Gardens, Victoria Street, S.W.1. Rebates of freights on goods for exhibition have been arranged by Messrs. Buckney, ranging from 20 to 50 per cent, according to date of shipment. Intending exhibitors should lose no time in communicating with Messrs. Buckney, who are prepared to arrange all details, supply attendant staff at Tokio, and safeguard exhibitors' interests in every possible way.

New Patents.

THIS List is specially compiled for the *Chemical News* by Messrs Rayner & Co., Registered Patent Agents, of 5, Chancery Lane, London, W.C.2., from whom all information relating to Patents, *Trade Marks and Designs can be obtained gratuitously.*

Latest Patent Application.

32859—*Bichowsky, F.*—Processes of producing titanium nitrogen compounds. December 7.

Abstract Published this Week

Ammonium Sulphate.—Patent No. 170613.—Some improvements in processes for the production of Ammonium Sulphate have been invented and Patented by Mr. P. Parrish of The South Metropolitan Gas Co., 709, Old Kent Road, London. In the production of ammonium sulphate by passing into a saturator gases which are liable to contain cyanogen compounds, the cyanogen compounds are prevented from reaching the saturator by adding to the ammoniacal liquor to be distilled a polysulphide, or forming a polysulphide in the liquor, for instance by adding sulphur or blowing in air, so as to fix the cyanogen compounds in the liquor as sulphocyanides; or the vapour from the still may be passed over spent oxide on its way to the saturator. In the case of the direct process, the ammonical gas is passed through a washer containing a polysulphide solution.

Messrs. Rayner & Co., will obtain printed copies of the published specifications and will forward on post free for the official *price of 1/- each.*

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